National Institute of Standards and Technology

Retail Motor-Fuel Dispensers and Consoles

Inspector's Manual

Revision-July 2003

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CHAPTER 1

INTRODUCTION TO THE COURSE

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Identify the purpose and objectives of this course.

2. Identify the prerequisite knowledge and skills necessary to comprehend the content of the course.

The National Training Program

As a weights and measures official, you are responsible for enforcing the system of weights and measures in the United States. You are probably aware that enforcement is a function of State and local jurisdictions rather than the Federal Government. However, the National Institute of Standards and Technology (NIST) has a mandate to provide technical assistance and advice to promote measurement uniformity and traceability of standards. Historically, training has been part of NIST's approach to providing this technical assistance and advice. In addition, NIST provides technical assistance to the National Conference on Weights and Measures (NCWM) in partial implementation of its statutory responsibility for cooperation with the States in securing uniformity in weights and measures laws and methods of inspection among the State and local jurisdictions.

Technological advances, especially in the area of electronic devices, have increased the need for training weights and measures officials. NIST course materials are available in a variety of technical areas to meet the specific training needs of individuals or groups. These courses are intended to:

- promote inspection and regulatory uniformity, and

- provide weights and measures officials with the knowledge and skills they need to deal with and benefit from changing technologies.

The courses are designed primarily to provide structured and uniform training for new employees in the weights and measures field. However, the experienced official will benefit from refresher training and upgrading of skills. A series of "functional courses" provides detailed instruction on specific functions of weights and measures officials such as inspecting and testing different types of equipment. Another series of courses covers basic information such as background, theory, and policy on weights and measures related subjects. In some cases, the training provided by the basic courses may prepare an official to take the functional courses. In other cases, the basic courses are intended as follow-ups to the functional courses. The contents of the following courses are directly relevant to the one you are now using:

Introduction to NIST Handbook 44
Introduction to Electronic Weighing and Measuring Systems

Course Objectives

Each day millions of Americans purchase one commodity that has become absolutely essential in our mobile society—motor fuel. Several times a month, most of us drive in to the neighborhood service station, or pull up to the pumps at an "oasis" on the interstate, and say, "fill er up," or "five dollars of regular," or—perhaps more often these days—we just get out of our cars and do the work ourselves. In many instances we pay by credit card or cash at the "pump" without any contact with station personnel. We may grumble about having to pay so much for a gallon of gas and having to pump it ourselves, and most of us shop around the best prices and look forward gleefully to the occasional "gas war." But, as dependent as we have become on motor fuels for our livelihood and pleasure, and despite the hundreds of dollars we each pour into our tanks every year, few of us feel any real concern that we may not be getting what we are paying for.

Perhaps because we take it for granted that we are getting what we pay for, few of us realize that we owe our peace of mind, in this regard at least, to two things: the precision instrument that we think of—if we think of it at all—as the "gas pump", and the efforts of the weights and measures officials who periodically inspect and test these devices to assure that they are operating at the high levels of accuracy and reliability for which they are designed.

As a weights and measures official, you serve both the purchasing public and the members of the commercial community who sell to the public, by assuring equity in the marketplace, discouraging unfair competition, and promoting consumer confidence.

So your job is more important than many people may realize, but it is also challenging work, requiring knowledge, skills, and judgment. You must master the complexities of the exacting technical specifications, tolerances, and procedures that have been established for your jurisdiction. You must be able to use precision test equipment expertly. And, you must perform your tasks judiciously, in such a way as to assure the protection of the public, and at the same time minimize the burden of inspections and tests to the user of weighing and measuring devices, realizing that any costs incurred by users as a result of your activities will ultimately be passed on to their customers.

So it is not enough simply to master procedures, as important as they may be. You must also understand something of how the business and marketplace work. And it is not enough to learn specifications and tolerances. As you will see in the following chapters, you must be able to recognize and distinguish between various types and classes of devices before you can decide which particular specifications and tolerances apply in a given situation. And you must also, to do your job well, understand the entire fuel-dispensing system, of which the measuring device is only a part.

Finally, you must keep up-to-date with a constantly changing and evolving technology. As you are probably aware, the "high-tech" electronic revolution, which in recent years has extended to every sector of our economy and has entered our schools and homes as well, has not passed over the retail motor-fuel dispensers industry. So you must be prepared to deal with frequent changes in already complex and highly sophisticated systems.

You should understand, however, that the purposes and objectives of this course are limited. It is not intended to train you as a mechanical or electronic technician, repairperson, or troubleshooter. Its primary purpose is to help you perform the no less important job of a weights and measures official.

Upon completion of the course, you should have the knowledge and skills to:

- Describe the different types of retail motor-fuel dispensing systems.
- Describe the major components of a retail motor-fuel dispensing device.
- Identify the appropriate equipment for testing a retail motor-fuel dispensing system, and describe the proper use and care of the equipment.
- Describe and use proper safety practices when working at the inspection site.
- Describe the inspection procedures that should be followed in the course of examining a retail motor-fuel dispensing system.
- Describe the steps for the testing of a retail motor-fuel dispensing system.
- Identify the post-test tasks that must be performed as part of an official field examination.
- Understand the Field Training component of this training program and requirements for certification as an inspector for retail motor-fuel devices.

Prerequisites

No previous knowledge of fuel-dispensing systems or retail motor-fuel devices is required. You should, however, be familiar with the general content and format of the latest edition of NIST Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices." If you are not familiar with Handbook 44, it is recommended that you study "Introduction to NIST Handbook 44", a self-study course which has been developed specifically for this purpose.

SUMMARY

This training course is part of a series of technical courses provided by the National Institute of Standards and Technology. It is intended to help you learn to perform the important task of examining retail motor-fuel dispensers and consoles in the field.

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CHAPTER 2

RETAIL MOTOR-FUEL SYSTEMS

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Define the following terms:
   - motor fuel
   - motor-fuel device
   - retail device
2. Identify the functional components or standard features of retail fuel-dispensing systems.
3. Differentiate between self-contained pump and remote dispenser types of fuel-dispensing systems.
4. Describe the difference between single-product and blended-product motor-fuel dispensers.
5. Recognize the features of electronic fuel-dispensing systems.

Retail Motor-Fuel Devices

This course deals with retail motor-fuel devices, one of several different classes of liquid-measuring devices for which specifications and tolerances are established in NIST Handbook 44 (Section 3.30.).

Retail motor-fuel devices are familiar to everyone by their everyday name—"gas pumps"—and for convenience, we can use this comfortable, if unglamourous, name without fear of being inaccurate. But all liquid-measuring devices are not gas pumps. For example, other liquid-measuring devices covered by this code include: wholesale meters (loading-rack meters), slow-flow meters, and lubricant devices. Different inspection and test procedures apply to each type of device. So, to avoid confusion, let's begin with some definitions, taken from Handbook 44 (Appendix D).

motor fuel. Liquid used as fuel for internal-combustion engines.

When we think of internal-combustion engines, the automotive engine—which powers cars, trucks, buses, and so on—probably comes first to mind. But internal-combustion engines also drive other types of vehicles, like boats, airplanes, helicopters, and some trains. And they are used as the power source for a great variety of machinery, like lawn mowers, chain saws, generators, farm equipment, compressors, and so on.

The most commonly used fuel for internal combustion engines is gasoline. But other liquid fuels, including diesel fuel, gasohol, and kerosene, come under our definition.

The term "motor-fuel device" is also defined in Handbook 44. A motor-fuel device must be designed both to measure and to deliver motor fuels. So a flow meter installed in a gasoline pipeline is not a motor-fuel device, since it does not deliver the product.

> **motor-fuel device or motor-fuel dispenser or retail motor-fuel device.** A device designed for the measurement and delivery of liquids used as fuel for internal-combustion engines. The term "motor-fuel dispenser" means the same as "motor-fuel device"; the term "retail motor-fuel device" applies to a unique category of device (see definition of "retail device").

The terms "motor-fuel device" and "motor-fuel dispenser" are used interchangeably in the Liquid-Measuring Devices Code (LMD). However, an important distinction is made between retail and wholesale devices. This distinction must be clearly understood, since many requirements in the LMD Code differ in substance or application depending upon which class the device being examined belongs to.

> **retail device.** A device for:
>
> single deliveries of less than 378 L (100 gal),
>
> retail deliveries of motor fuels to individual highway vehicles, or
>
> single deliveries of liquefied petroleum gas for domestic use and liquefied petroleum gas or liquid anhydrous ammonia for nonresale use.

In general, retail devices are distinguished from wholesale devices, which may be of similar design, but are used to deliver product—usually in large quantities—that is intended for resale. So, for example, a motor-fuel device that is used to measure gasoline as it is being loaded into a tanker truck for delivery to a gas station would be considered a wholesale, not a retail, device, since the gasoline will be sold again. Separate specifications and tolerances for wholesale devices recognize differences in design characteristics and operating conditions associated with delivering large quantities of motor-fuel products.

Our definition includes all motor-fuel devices that are used for retail deliveries to highway vehicles, from motorcycles to the largest trucks, which may be equipped with multiple fuel tanks. But it also includes any motor-fuel device that is designed for deliveries of less than 100 gallons. So a gas pump installed at a marina to service boats, or at an airport to service private planes, is considered a retail device if it is designed for deliveries of less than 100 gallons. Again, these classifications are based on design characteristics and typical operating conditions, not exclusively on the type of business (wholesale/retail) in which the device is used.

The Fuel-Dispensing System

The design of the fuel-dispensing system for a gas station depends on a number of factors, including the size of the facility, its volume of business, the number of different grades, blends, or separate motor-fuel products sold, the desirability of such features as self service, remote cashiers, prepayment, multi-tier pricing—offering the same product at more than one price per gallon, depending upon the delivery and/or payment method (cash/credit, etc.)—and so on. So some systems are quite complex, others relatively simple. But all retail fuel-dispensing systems have three basic components: storage tanks, pipelines, and dispensers, as illustrated in Figure 2-1.

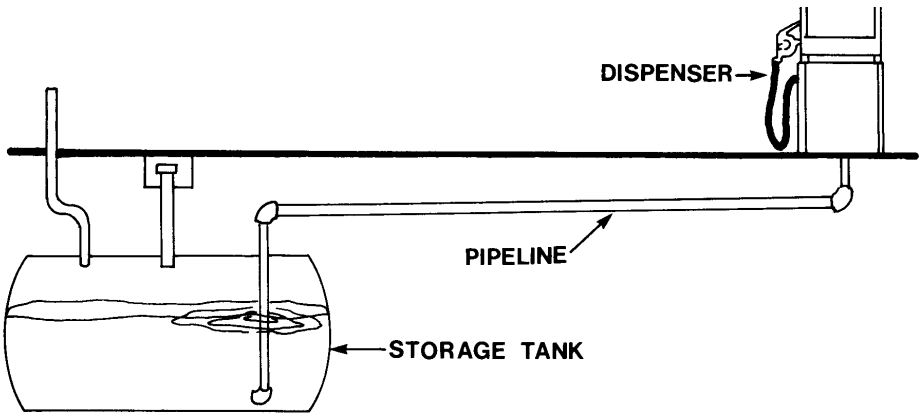


FIGURE 2-1. BASIC COMPONENTS OF THE FUEL-DISPENSING SYSTEM

At the present time, most storage tanks at retail motor-fuel facilities are installed underground, like the one shown in Figure 2-2. This location protects them from extreme temperature variations and from the dangers of accidental collision or fire, and permits aboveground space, which may be very valuable, especially in urban areas, to be used most efficiently. However, changes in Federal environmental protection regulations may encourage some facilities to install aboveground storage tanks in the future, since maintenance, including detection, containment, and cleanup of leaks is much easier when tanks are located aboveground.

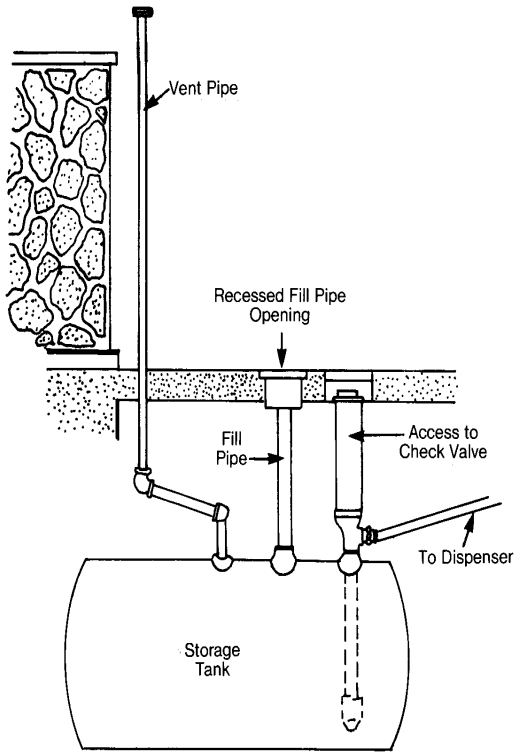


FIGURE 2-2. THE STORAGE TANK

Whether installed above or below ground, there is usually a separate storage tank for each grade or type of fuel sold at the station, except at stations that employ special equipment to produce blended products (described below). The size of a storage tank depends on the space available and the retailer's needs. Large storage tanks hold as much as 12,000 gallons of fuel (slightly more than 1,600 cubic feet).

When the tank is filled, the rising liquid level acts like a piston, pressurizing air and vapor in the upper portion of the tank. Conversely, as product is drained during delivery, the falling liquid level reduces the pressure. Without venting excessive pressure buildup could strain the tank and possibly cause leaks, and a pressure deficiency could strain the pumping mechanism and even make delivery through the system impossible, or encourage vaporization in the delivery lines. To prevent these conditions, storage tanks have vent pipes, which allow pressure within the tank to be maintained at a desired level (usually slightly above atmospheric pressure). The vent line is generally equipped with a relief valve, which opens at the preset pressure to permit air and vapor to be expelled from the tank into the atmosphere or air to be drawn into the tank from the atmosphere, as necessary.

In many States (or geographical areas), environmental protection regulations also require motor-fuel dispensing equipment to be equipped with vapor recovery systems, which prevent venting of vapor to the atmosphere during normal operation by balancing pressures between the discharging and receiving tanks. We will look more closely at vapor-recovery devices in the next chapter.

Storage tanks are filled periodically, usually from tanker trucks. In the case of underground tanks, a fill pipe (see Figure 2-2) extends from the tank to a level just below the pavement surface, where it is easily accessible, but safe from accidental impact from vehicles moving through the station. Fill pipes must be clearly labeled and/or color-coded to assure that the correct grade of fuel or fuel product is delivered. And they must be securely capped, to prevent contamination by dirt and moisture. In many States, over-fill containment is also required for below-grade fill pipes. Checking the labeling and security of fill pipes is one of the tasks specified in your inspection procedures.

Fuel travels from the storage tank to the dispenser through underground pipelines, which rise to the surface directly beneath the dispensers to avoid any risk of impact by a vehicle approaching or leaving the service island. Since a single storage tank can serve several dispensers, this piping may be quite extensive. It must be designed and installed with care to minimize the danger of fuel leaks.

Pipelines must also be buried far enough below the surface—usually at least 18 inches—to avoid a significant temperature differential between them and the storage tank. Liquid fuel tends to vaporize when heated. This is especially likely to occur in a particular type of dispenser, called a self-contained pump (described further below), in which fuel in the pipeline is under negative (suction) pressure. Under these conditions, fuel traveling from a relatively cold storage tank through warmer pipelines can vaporize, resulting in a condition called “vapor lock.” This condition sometimes occurs in automobile fuel lines, especially in very hot weather, for the same reason. If you have ever experienced vapor lock in your car, you know the result—fuel does not reach its intended destination. This disappointing result can also occur in fuel-dispensing systems that have not been properly installed.

The dispenser is the heart and brain of the fuel delivery system. It is also the component you will be primarily concerned with when conducting field examinations. As it delivers fuel to a vehicle through a specially designed hose and nozzle assembly, the dispenser simultaneously measures the volume and computes the price of the product delivered. The dispenser also contains a variety of control mechanisms, which regulate the rate of delivery, prevent over-fill and siphoning, and assure that the components that register volume and price are reset to zero at the beginning of each delivery.

The dispenser is a precision instrument, designed to register accurately within very close tolerances. You will see how this is done when we take a closer look at the dispenser and its operating components in the next

chapter. But first you need to know the characteristics of several different types of fuel dispensers that are in common use.

Self-contained Pumps and Remote Dispensers

When fuel is stored in tanks below the dispensers, it must be brought to the surface against the force of gravity. This is done in one of two ways. The liquid fuel can be "pulled" toward the dispenser by a suction pump located in the dispenser unit, as in Figure 2-3 (actually, the product is propelled toward the dispenser by atmospheric pressure above the liquid surface in the storage tank).

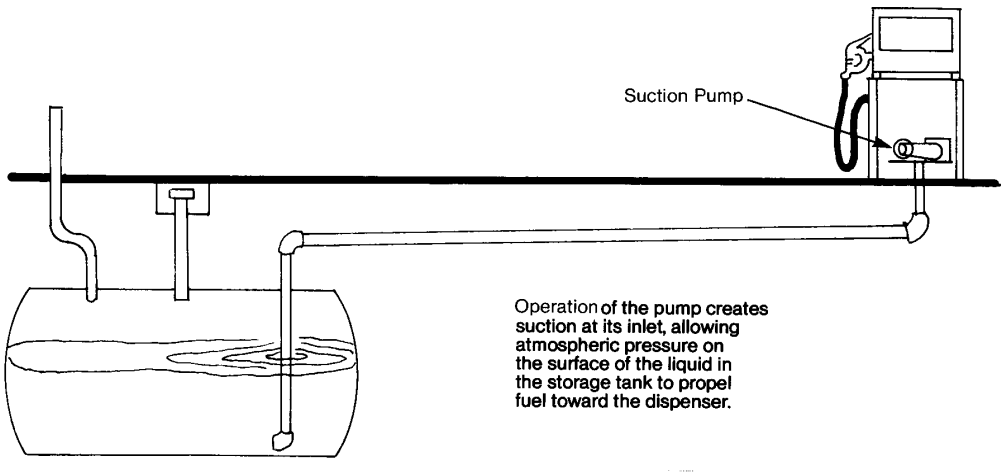


FIGURE 2-3. SELF-CONTAINED PUMP SYSTEM

A dispenser that contains a pump for drawing product from the storage tank is generally called a self-contained pump. A system in which fuel is pushed from the storage unit is usually called a remote-pump system, and the dispensers are commonly referred to as remote dispensers or dispensers. While, both types of dispensing systems are in common use, the majority of newer installations are equipped with remote dispensers. Both types have certain advantages and disadvantages.

When several dispensers are served by one storage tank, a single remote pump can supply product to the entire system, as illustrated by the system diagramed on the left in Figure 2-5. In a self-contained pump system, on the other hand, like the system diagramed on the right, each dispenser has its own pump, regardless of how many dispensers are served by the same storage tank. Alternatively, product can be pushed toward the dispenser by a pump located in the storage tank, as in Figure 2-4.

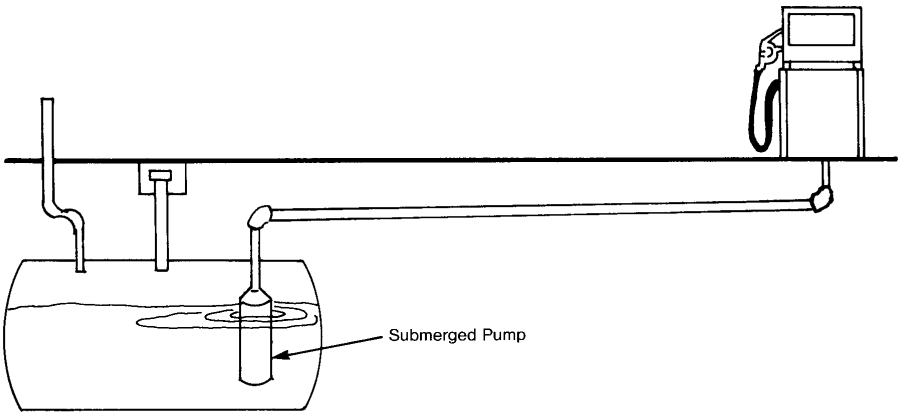
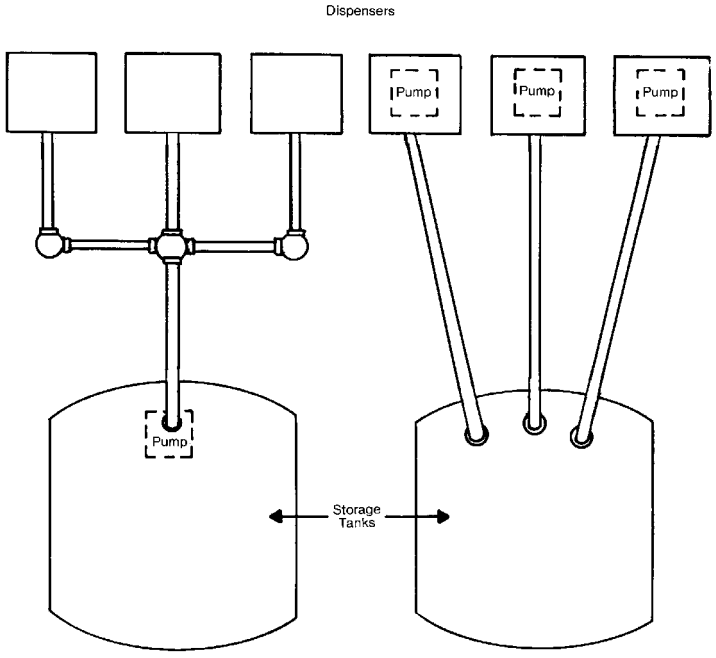


FIGURE 2-4. REMOTE DISPENSER SYSTEM

Over the life of the system, a single pump will obviously require less maintenance than several separate ones. So in a multi-dispenser system like the one illustrated in Figure 2-5, the remote pump seems to have a clear advantage. However, consider what will happen if that single remote-pump breaks down: the entire system will have to be taken out of service while repairs are being made. In a suction pump system, on the other hand, each dispenser operates independently, so if a pump malfunctions in one dispenser, the others can remain in service while repairs are made.

Deciding which type of system to install involves weighing the initial cost against long-term efficiency. But since each type has certain advantages in particular situations, you will find both used in the field.



Remote Pump Dispenser System

Self-Contained or Suction Pump System

FIGURE 2-5. MULTI-DISPENSER SYSTEMS

Dual-product Dispensers

Most service stations sell several different motor fuels: unleaded gasoline, often diesel fuel, sometimes gasohol, and even kerosene. In addition, gasoline is usually available in different grades: regular and premium, and often in intermediate grades. Each different product or grade can be held in a separate storage tank, and carried to dispensers through a separate pipeline.

Often, two complete dispenser assemblies are housed in a single chassis. These are called dual dispensers (they are also known as twins or duos). If each dispenser delivers the same product or grade, the unit is generally referred to as a single-product dual dispenser (or just 1-dual, twin, or duo for short). If the dispensers deliver different products or grades, the unit may be called a two-product dual dispenser (or 2-dual, twin, or duo).

Two-product dual dispensers (like the one on the right in Figure 2-6) are not, strictly speaking, variations on the basic configuration described above, since each dispenser is independent, having its own components and pipeline connection. But in a self-contained pump system, one-product dual dispensers (like the one on the left) may share a single pump, and, therefore, a single pipeline connection, as illustrated in Figure 2-7. This design reduces the number of suction pumps needed for a multi-dispenser system, but each dispenser must be equipped with its own control valve so that it can be operated independently. Figure 2-8 shows typical mechanical and electronic dual dispensers that you will encounter in the work place.

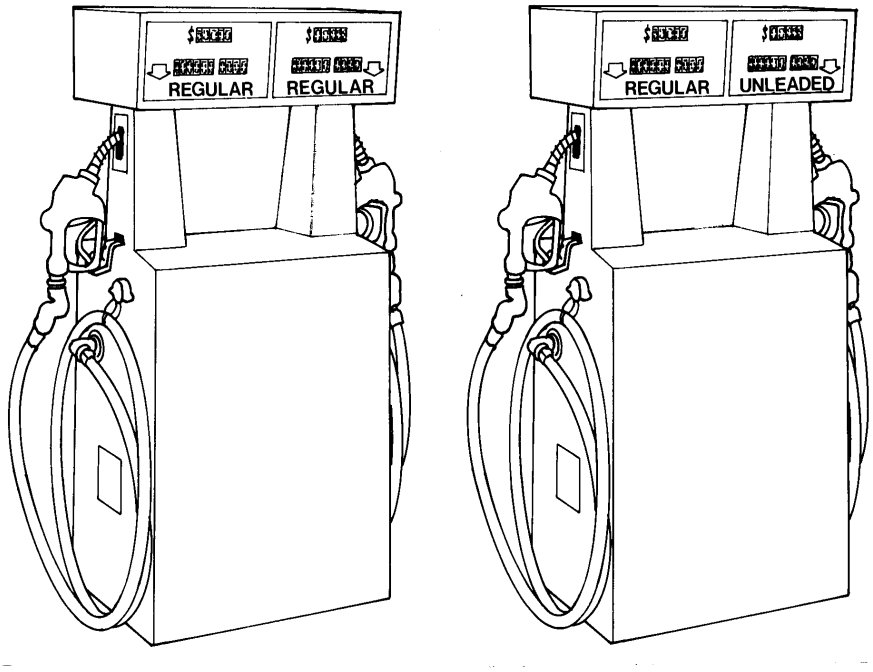


FIGURE 2-6. 1- AND 2-PRODUCT DUAL DISPENSERS

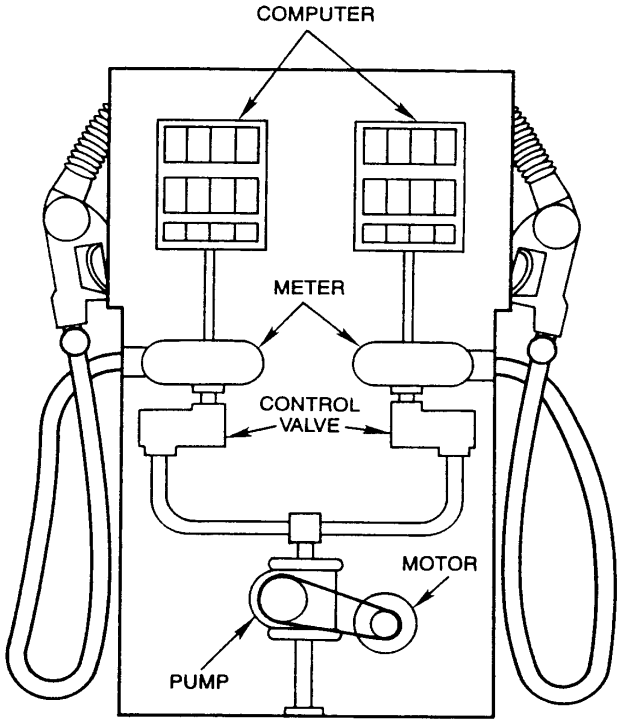


FIGURE 2-7. SINGLE-PRODUCT DUAL DISPENSER

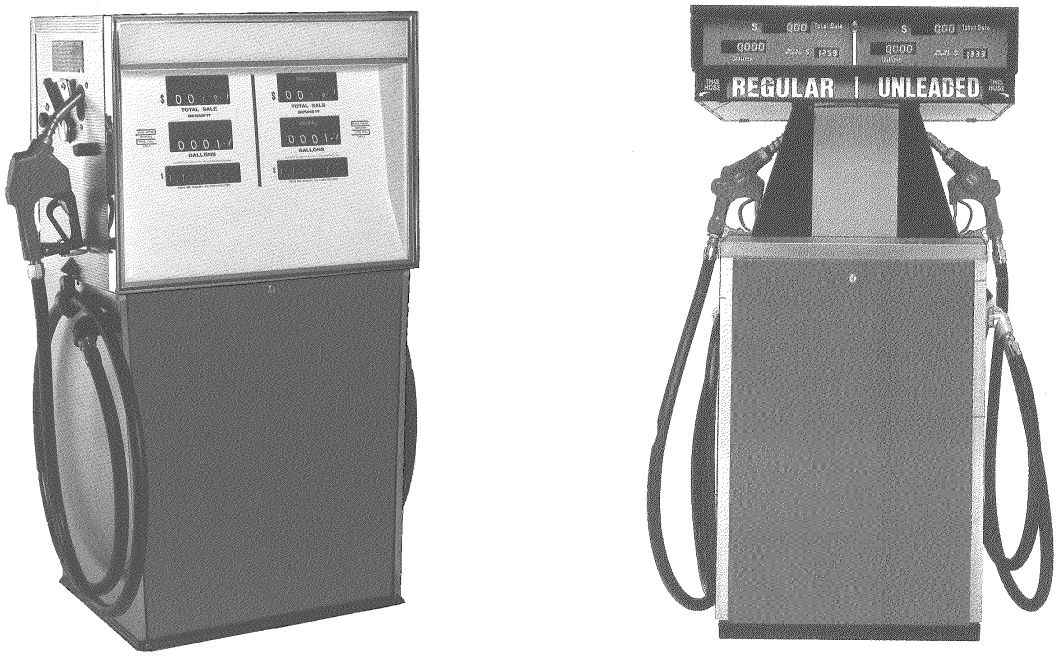


FIGURE 2-8. TYPICAL DUAL PRODUCT DISPENSERS

Multiple-product dispensers

For the past several years the most popular type of dispenser, especially in larger fueling outlets, has been the multiple-product dispenser. Here several grades of fuel may be selected from two, three, or even four hoses on the same dispenser. Though only one grade of fuel can be selected from a dispenser face at a given time, marketers and consumers alike have found having all grade available at a single fueling point is desirable. Figure 2-9 shows the typical fuel flow through a three hose multiple-product dispenser.

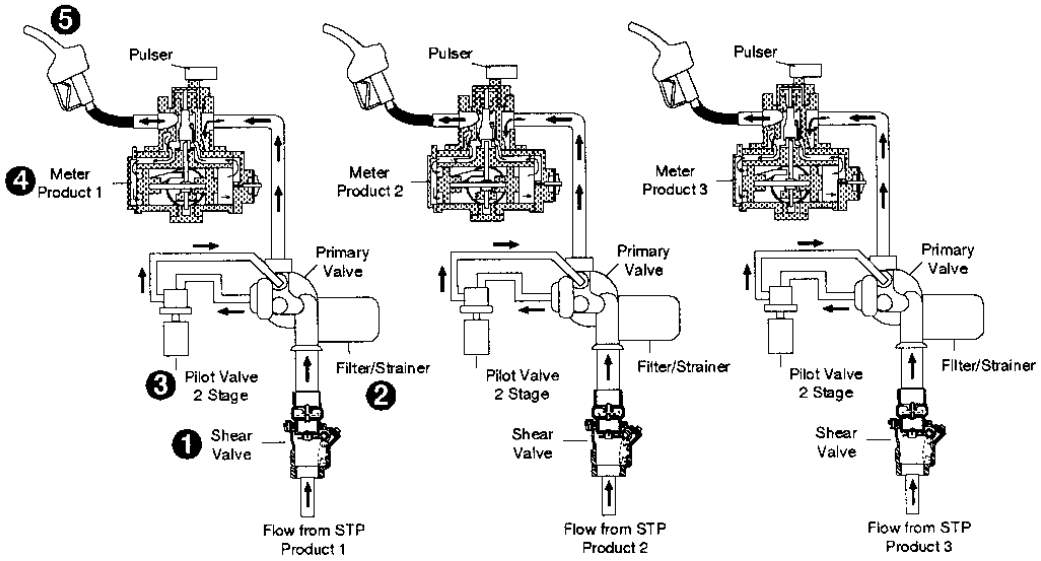
1 Fuel passes through a shear valve then enters dispenser.

2 Fuel flows through a strainer and filter.

3 Filtered fuel passes through a two-stage solenoid and primary valve (earlier models use a check/relief valve and parallel shutoff and slowdown solenoid valves).

4 The meter measures fuel flow.

5 Fuel discharges through the nozzle.



How a dispenser works

FIGURE 2-9. HOW A MULTIPLE PRODUCT DISPENSER WORKS

With the multiple-product dispenser one set of electronics and one electronic computer controls all hoses on a particular side (fueling point) of that dispenser. A more recent variation of the multiple-product dispenser has been a "single-hose" version. With the single hose version, all grades of fuel come together into a manifold supplying a single hose. Later when we take a closer look at EPO 21, you will see that provision is made for a 0.3 gallon flush before taking a sample for fuel quality testing. Figure 2-10 depicts three grade/three hose and three grade/single hose dispensers.

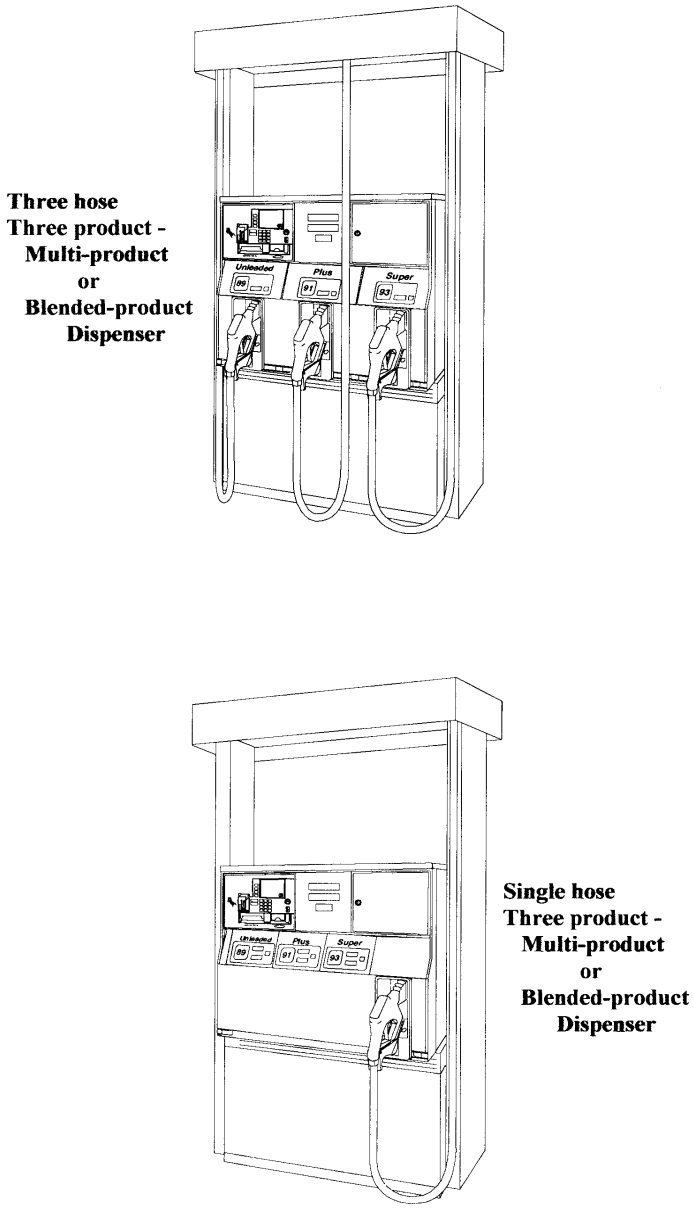
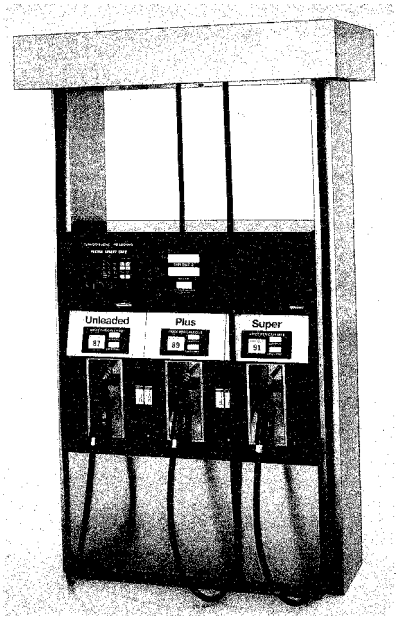
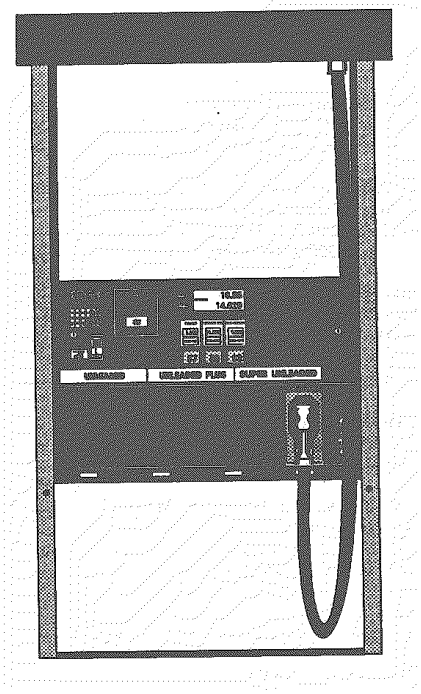


FIGURE 2-10. TYPICAL MULTIPLE-PRODUCT DISPENSER CONFIGURATION

Multiple-product dispensers may be furnished in either self-contained or remote pump versions. The remote pump version is the most popular. With the multiple product pump or dispenser, each grade of fuel has its individual hydraulic system, refer back to Figure 2-9.

Figure 2-11 shows the exterior of several multiple-product dispensers from different manufacturers. The interior configuration of the piping systems as shown in Figure 2-12 is typical of that used in these dispensers.





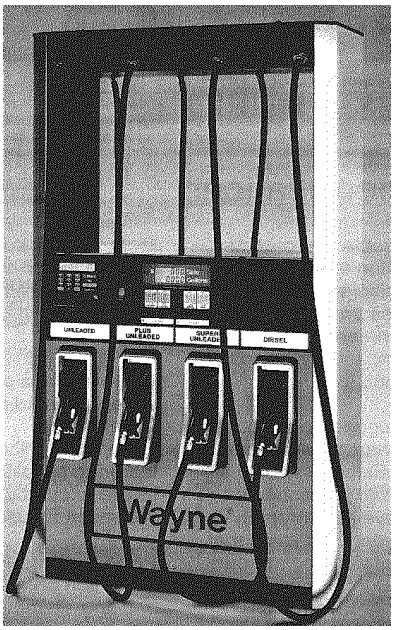


FIGURE 2-11. TYPICAL MULTI-PRODUCT DISPENSER, EXTERNAL

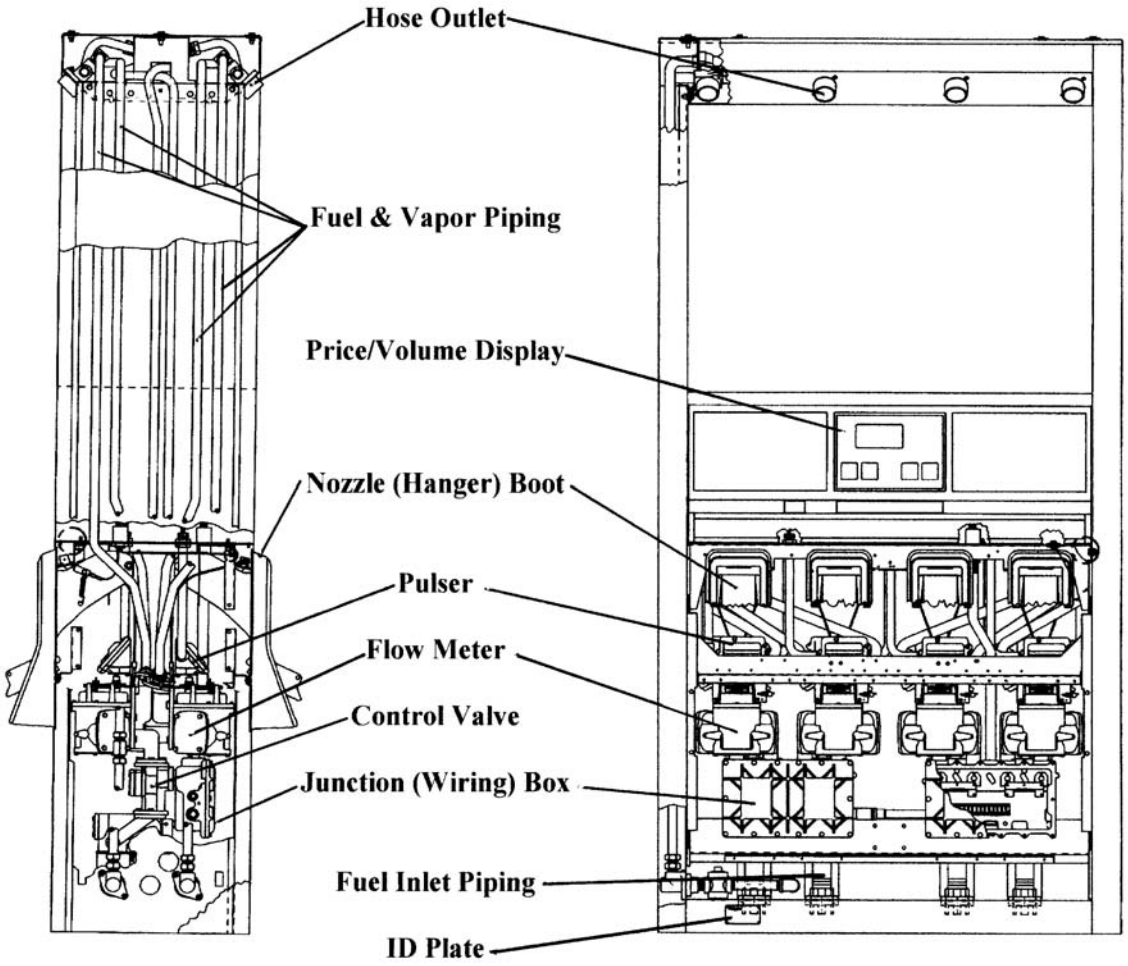


FIGURE 2-12. TYPICAL MULTI-PRODUCT DISPENSERS, INTERNAL COMPONENT

While the interior and exterior of dispensers or pumps from several manufacturers may differ in details of appearance, the basic operation of the dispensers are very similar. With some manufacturers a lever or handle is lifted or rotated to start the dispenser. With other manufacturers pressing a start button or grade selection icon or decal puts the unit into operation. Safety regulations prohibit the dispensing of fuel by merely removing the nozzle from its hang-up position. Another separate action is required, pressing a start button, selecting a grade of fuel, lifting or rotating an operating mechanism, etc.

Blended-product Dispensers

For many years, some retailers have offered blended products, which are produced by blending different grades of the same fuel at the pump. So, for example, a high-octane grade of gasoline can be blended with a low-octane grade in different proportions to produce a number of intermediate grades. (Of course, the component products that are blended must be of the same basic type: different grades of leaded and unleaded gasoline can not be blended.) The customer selects the desired blend by pressing a pushbutton, a grade selection decal, or in the case of older mechanical blenders by operating a control knob or handle.

Like the multi-product dispenser, an obvious advantage of blended-product dispensers is that all product grades can be available at each dispenser, so the customer at a busy station does not have to wait for a pump that carries his or her grade while other pumps remain idle. Another important advantage is that fewer separate storage tanks are required: instead of one tank for each distinct grade, product supplied from two tanks can produce several distinct grades. This latter factor, along with the stricter regulations regarding storage tanks referred to earlier, is likely to encourage more widespread use of blended-product dispensers in the future.

Figure 2-13 illustrates a typical hydraulic system for a fixed ratio blended-product dispenser. This particular illustration shows the fixed ratio valve on the inlet side of the low and high octane product, with the blended output being metered. When the customer selects the high- or low-grade product (by operating the control for that hose), the control valve for that supply is actuated so as to pass product to the meter for the selected product. If the intermediate grade is selected, the control valves are actuated in such a way as to direct supplies of both component grades, in correct proportion for the blend, to a separate meter.

Fixed ratio blender

1 Fuel passes through a shear valve then enters dispenser.

2 For straight product fuel flows directly to a strainer and filter.

3 For blended product fuel flows through strainer/check valve assemblies. These assemblies clean fuel and prevent tank cross flow.

4 Fuel enters blend valve through inlet A and B.

5 The orifices and equalizing piston control flow from each tank. The orifice combination maintains the fixed blend ratio.

6 The fixed ratio fuel flow passes through check valves then mixes in the blend manifold.

7 Straight product and blended product pass through the filter and strainer assembly.

8 Filtered fuel passes through a primary valve controlled by a two-stage pilot valve.

9 The meter measures fuel flow.

10 Fuel discharges through the nozzle

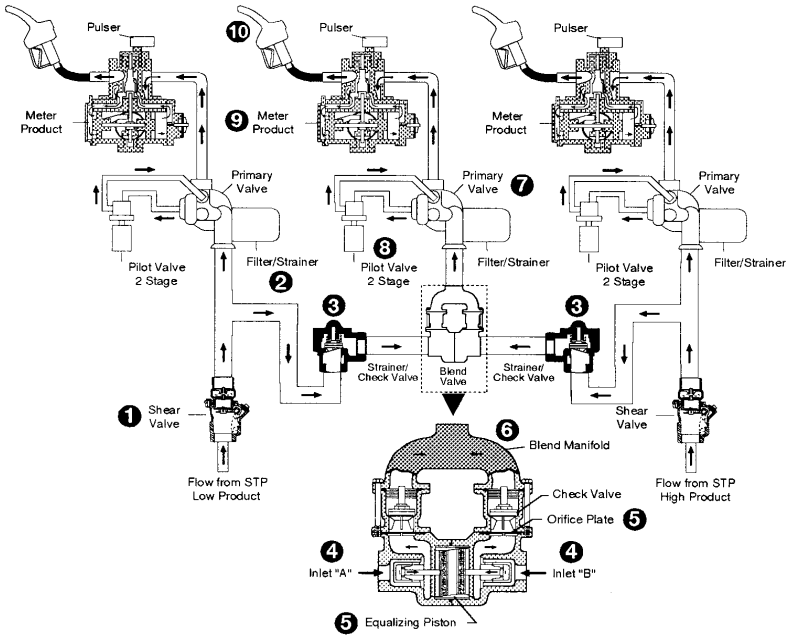


FIGURE 2-13. FIXED BLENDER

A variation is to have the ratio valve on the discharge of the two meters, in this case the computing device, which registers the quantity of the delivery and displays the quantity, total price, and price per gallon, is driven by the component product meters simultaneously. Thus the output of both meters electronically added to give the total blended throughput, and the blended product is not metered. Some fixed ratio blenders use the same electronic proportioning for the intermediate grade as is used by their variable ratio counterpart discussed below.

As will be shown later the dispenser may consist of an individual hose for each product or products may come together at a manifold just prior to the dispenser outlet to the hose and allow for a single hose to dispense any of the products. As mentioned under the single hose multiple-product dispenser, when we take a closer look at the EPOs you will see in EPO 22 that provision is made for a 0.3 gallon flush before taking a sample for fuel quality testing.

Blenders may also be of the variable ratio type and provide, in addition to the two base products, up to three or more (usually a maximum three) intermediate blended products may be delivered from the same dispenser. With the variable ratio blender the use of a single hose is quite common. In some instances a single hose is provided for all the products with an additional hose provided for the highest grade component. Figure 2-14 shows the hose configuration for a three hose blender (top), a system with one hose for the blended products

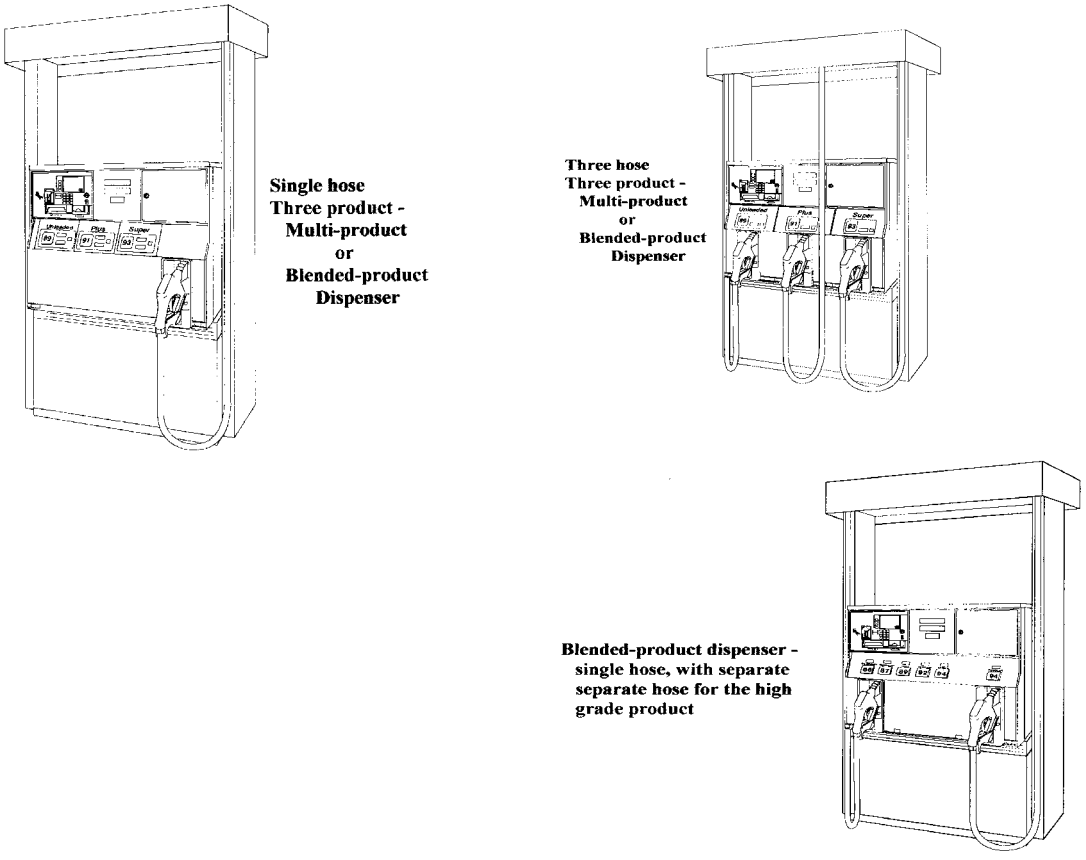


FIGURE 2-14. BLENDER, HOSE CONFIGURATION

and a separate hose for the high octane product (bottom), and a system with a three product blend with single hose for all three products (center). The arrangement shown at the bottom would generally represent a fixed ratio blender configuration.

Figure 2-15 represent single and multiple hose arrangements for several blender types. Without observing the internal piping it is often difficult to determine whether the unit is a fixed ratio blender incorporating a fixed blend ratio valve, a variable blend ratio valve, or whether the unit is a standard multi-product dispenser.

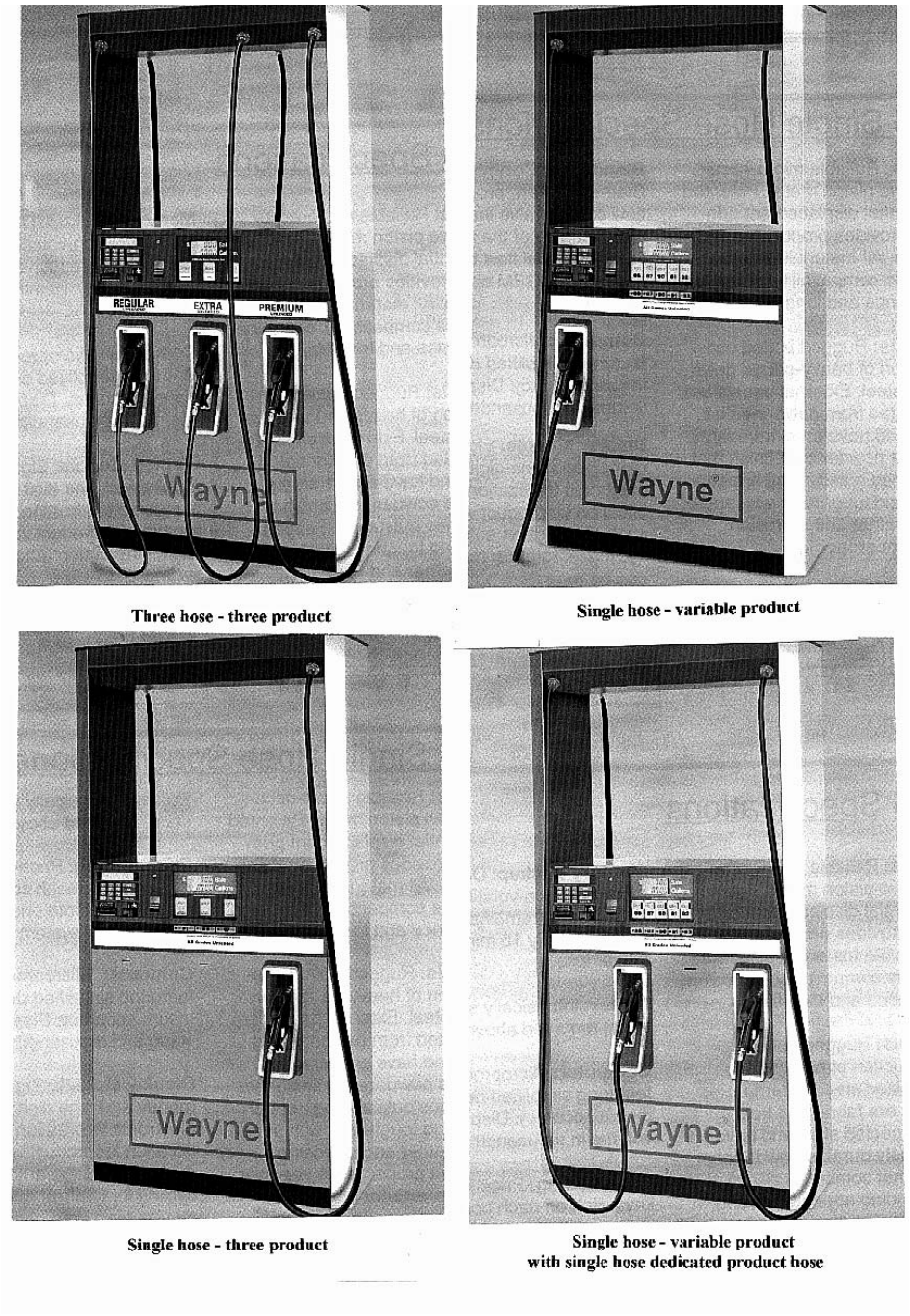


FIGURE 2-15. SEVERAL BLENDER TYPES

Mechanical and Electronic Fuel Dispensers

Currently the majority of new installations are electronic fuel-dispensing systems. Mechanical systems are for the most part found in smaller or older retail outlets. Electronic systems have many advantages that can repay the relatively high cost of investment in a short period of time. The demands of new and expanding marketing concepts can be advanced by electronic technology in relatively short development times.

Because they have fewer moving parts, electronic dispensers generally require less maintenance than mechanical dispensers. They also have high pricing capacity (up to $9.999/gal), another attractive feature, especially in times of frequent and wide fluctuations in fuel prices. And they can register fuel deliveries in very small amounts (thousandths of a gallon, or tenths of one cent) with great accuracy. Too, changes to metric measurement and foreign currency types are more readily handled by the electronic computer.

Another advantage of electronic systems in today's marketplace is that they facilitate multi-tier pricing, the practice of offering the same product at two or more different prices depending upon the delivery and payment method selected by the customer (full serve/self serve, cash/credit), which became widespread in recent years. We will look more closely at the issue of multi-tier pricing in Chapter 5.

Electronic dispensers also have the capability for connection to a variety of electronic input and output devices, like remote readouts, control consoles, and data storage, management, and communication systems. Using these powerful devices, a single attendant can control a number of dispensers at the same time, from a single console installed at a remote location, like an enclosed cashier's station. Readouts on the console show the operator the operating status of each dispenser, the amount of fuel delivered, the price per gallon, and the total price.

In some electronic systems, the operator can pre-set individual self-service pumps to deliver a specific amount of fuel, either by total price or by volume, so that the customer can pay in advance, before filling his or her tank. Many systems can record and store sales data by shift, product, type of sale (cash/credit card), and so on. These data can then be stored electronically at the facility, or transmitted directly to a central data storage facility, located across town, or in another city. Thus the system becomes an invaluable business management tool in addition to serving its function of customer service at the fueling outlet.

The utilization of electronic fuel-dispensing systems with such extended capabilities can reduce labor costs significantly, especially in a large facility, and can also provide greater security and more effective management through enhanced inventory control. And because most electronic systems are modular in design, features can be added to the system without replacing existing equipment.

We will take a closer look at electronic dispensers and control consoles later in this course. To conclude this introduction, let us consider one major difference between mechanical and electronic dispensers that affects the specific requirements that are applied to these devices.

All indicating elements for weighing and measuring devices can be classified as either analog type or digital type devices, as defined in Handbook 44 (Appendix D):

analog type. A system of indication or recording in which values are presented as a series of graduations in combination with an indicator, or in which the most sensitive element of an indicating system moves continuously during the operation of the device.

digital type. A system of indication or recording of the selector type or one that advances intermittently in which all values are presented digitally, or in numbers. In a digital indicating or recording element, or in digital representation, there are no graduations.

Most mechanical dispensers have analog indicators. Their volume and price indicators are usually revolving wheels, one for each digit, as shown in Figure 2-16. If you observe a mechanical dispenser in operation, you will notice that while fuel is being delivered, the wheels for the smallest amounts (usually cents for price and tenths of a gallon for volume), which have graduations and an indicator, move continuously. So the fuel delivered is being measured and the price computed continuously, even though the amounts are not precisely indicated in the intervals between fixed graduations. For example, the total price wheels in Figure 2-16 indicate a delivery of between $14.06 and $14.07 of product. We could read it with confidence as indicating $14.065: greater precision is limited by the size of the wheel and the fact that the smallest graduated interval is one cent.

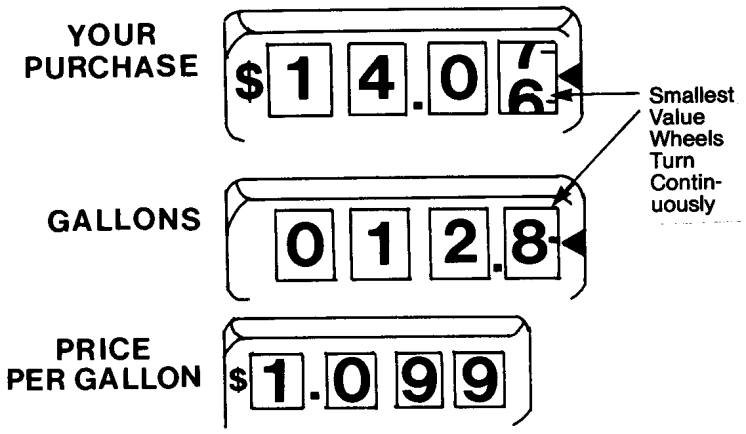


FIGURE 2-16. VOLUME AND PRICE INDICATOR, ANALOG INDICATOR

Electronic dispensers, on the other hand, has digital indicators. When you observe the indicator (like the one depicted in Figure 2-17), usually a liquid crystal or LED display, you will notice that it "jumps" from one value to the next (you may have to operate the pump very slowly to actually see this), even for the smallest amounts (usually cents and thousandths of a gallon) indicated. So, measurements are being indicated intermittently. For example, the indication of 1.476 gallons changes to 1.477 gallons with no intermediate indications.

Analog and digital indicators are equally capable of great—though never truly perfect—accuracy. But because of the difference in the way they indicate measurements, different specifications and tolerances are applied when testing them. We will discuss these further when we turn to actual test procedures, but it is important that you be able to recognize and distinguish between analog and digital fuel-dispensing devices, and that you understand what makes them different.

FIGURE 2-17. VOLUME AND PRICE INDICATORS, ELECTRONIC DIGITAL INDICATOR

SUMMARY

Retail motor-fuel devices are a class of liquid-measuring devices, commonly known as "gas pumps." Design and operating characteristics distinguish them as a class from other similar devices. The fuel-dispensing system consists of three components: the storage tank, pipelines, and dispenser. There are two basic types of systems: self-contained pump and remote dispenser systems. Several different dispenser configurations are in common use (single/dual product, multi-product, blended-product), each appropriate for particular applications. Blended-product dispensers and multi-product dispensers may have separate hoses for each blend (grade) of fuel or they may have separate hoses for each blend (grade) of fuel dispensed. Electronic fuel-dispensing systems are gradually replacing mechanical systems because of their efficiency and flexibility. Analog and digital indicators produce indications of quantities measured and total price in different ways. As a result, different specifications and requirements apply to them, as will be described in detail in later chapters.

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CHAPTER 3

COMPONENTS OF THE RETAIL MOTOR-FUEL DISPENSING SYSTEM

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Identify the major components of each of the following types of retail motor-fuel dispensing systems:
   - self-contained systems;
   - remote pump (or dispenser) systems; and
   - mechanical and electronic systems.
2. Explain the purpose and function of each of these major components.

INTRODUCTION

What the motorist sees of a modern fuel-dispensing system is very impressive—a metal cabinet, extending perhaps eight feet in height, lighted price and volume indicators, a length of hose or hoses, with nozzles on the end, push buttons, possibly a card reader, maybe even a small TV screen and instructions for operating the device. While the outward appearance may be impressive, the reality of the dispenser hydraulic, mechanical and electronic complexity is hardly recognizable.

Opening the cabinet reveals a profusion of components, tubing, wiring, gears, and linkages, enough to daunt even the mechanically or electronically minded amateur. In this chapter, you will learn to recognize these parts, and gain a basic knowledge of how they work together.

The fuel-dispensing system performs several interrelated functions. The purpose of some components is to maintain hydraulic continuity, to regulate the direction of flow and fluid pressure. Others are responsible for pressurizing the fuel and moving it through the system. Still others, of course, are involved in metering the liquid fuel, registering accurately the quantity delivered, and computing the price of the delivery. Finally, some components serve to control the operation of the system, switching it on and off, resetting the volume and price indicators, regulating the delivery, and so on. We will proceed to look at the major components in each of these functional areas.

HYDRAULIC CONTINUITY

Fuel-dispensing systems are designed to measure, register, and deliver accurately the desired quantities of fuel product. The customer is paying for motor fuel, not air or fuel vapor. So these gases must be prevented from entering the dispenser's metering device. In addition, in order to be able to lift the fuel efficiently from an underground storage tank to the dispensers—especially in a self-contained system—the pipelines must be essentially free of air and vapor.

The most practical means of eliminating these gases is to keep the entire system—from the storage tank to the delivery nozzle—filled with liquid fuel at all times, even when the system is temporarily idle, as it is between deliveries, or when the station is shut down overnight. This could be accomplished in a number of ways, but the most practical and efficient design incorporates a simple automatic valve, called a check valve. In the cutaway drawing shown in Figure 3-1, you can see how one works. When fuel entering the valve inlet is under sufficient pressure to push the valve off its seat against the resistance of a spring and the pressure of liquid on the opposite side, the valve is opened, allowing liquid to flow through the valve in the direction of the arrows. When the source of pressure difference ceases, flow will discontinue, and the force of the spring will reseat the valve, preventing liquid from flowing through the valve in the opposite direction.

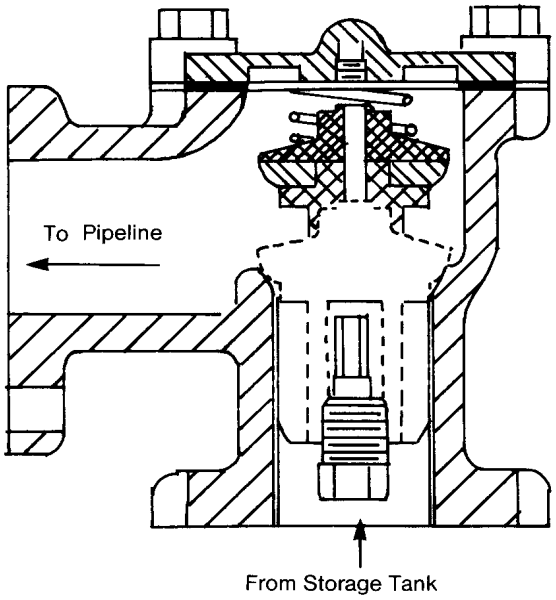


FIGURE 3-1. AUTOMATIC CHECK VALVE

In a fuel-dispensing system, a check valve permits liquid fuel to flow toward the delivery nozzle, but never back toward the storage tank. A check valve is located between the storage tank and the dispenser (as shown in Figure 3-2), usually close to the outlet of the storage tank, either at the angle joint where the pipeline drops vertically into the tank (self-contained systems), or inside the discharge manifold that sits atop a submerged pumping unit. (In some self-contained systems, a foot valve, located at the bottom of the intake pipe, performs the function of the check valve.)

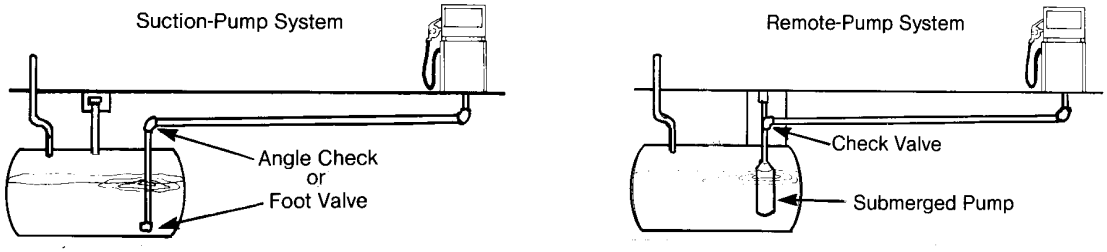


FIGURE 3-2. LOCATION OF SYSTEM CHECK VALVES

As we proceed through the system, you will see other automatic valves that operate in much the same way as these system check valves, functioning to regulate the direction of flow or fluid pressure of the product as it makes its way toward the meter and discharge hose. You will also see how a similar valve, located at the opposite end of the system, prevents fuel from draining from the discharge hose, assuring delivery of the full metered amount of fuel.

PRESSURIZING AND MOVING THE FUEL

In retail fuel-dispensing systems, a motor-driven pump furnishes the hydraulic pressure that moves fuel from the storage tank to the dispenser, through the metering device, and to the discharge hose and nozzle. As you know, two basic types of systems are in common use—self-contained and remote pump systems. Most of the systems you will encounter today will be remote pump systems. These lend themselves to larger multiple dispenser installations. However, let us take a look at each type.

Self-contained Systems

In self-contained systems, the pumping unit is located inside the dispenser. Its major components are:

- a pump
- an electric motor
- an air eliminator
- flow regulating valves

Several manufacturers produce a self-contained unit, which includes the pump, air eliminator, valves, and flow passages connecting them, all enclosed in a single casing, as in Figure 3-3. The electric motor is separate, and drives the pump by means of a belt and pulleys.

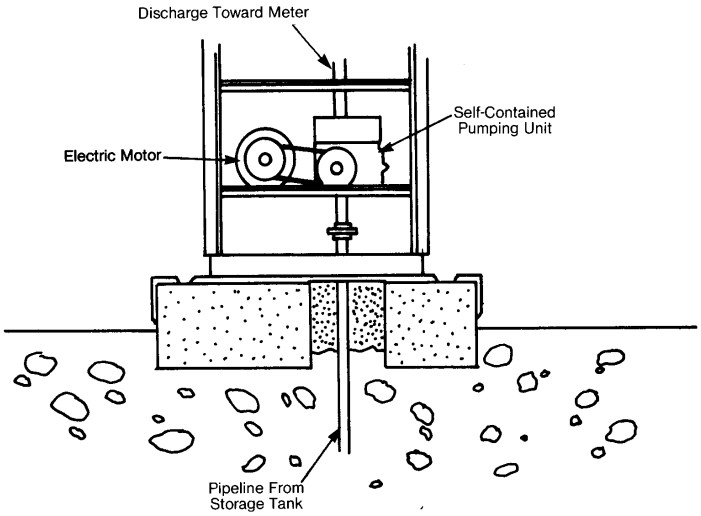


FIGURE 3-3. SELF-CONTAINED PUMPING UNIT AND MOTOR

The operation of a typical self-contained pumping unit is illustrated in Figure 3-4. When the dispenser's on-off switch is placed in the "on" position, the electric motor is activated, and begins to turn the rotary-vane pump (other pump types may be used). As the pump turns (clockwise in Figure 3-4), it propels fuel forward from its outlet. This displacement of the liquid creates a partial vacuum at the pump inlet.

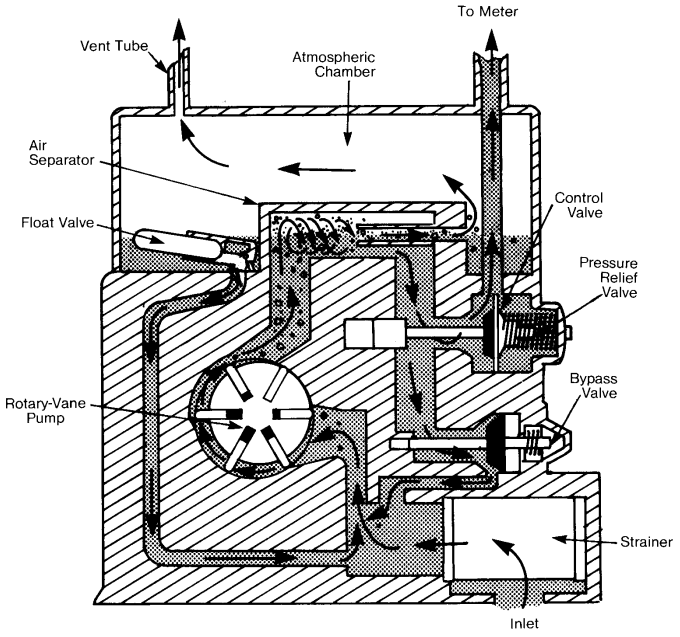


FIGURE 3-4. CUTAWAY OF TYPICAL SELF-CONTAINED PUMPING UNIT

As long as the discharge nozzle remains closed, this vacuum is relieved by fuel circulating continuously through the unit—you'll see how in a moment. But when the nozzle is opened, suction pressure is transferred instantaneously from the pump inlet all the way back through the pipeline to the storage tank. There, atmospheric pressure bearing on the surface of the fuel forces it to flow through the inlet pipe and check valve we saw earlier, into the pipeline, and toward the dispenser. As it enters the pumping unit, it passes through a strainer or filter, which removes any solid contaminants, and is drawn into the pump inlet.

Small quantities of trapped air and fuel vapor must be removed from the fuel before it passes to the meter. So, as it flows from the pump outlet, the fuel, now under pressure (typically 18-25 psi) enters the air separator chamber. The shape of this chamber forces the rapidly flowing fuel to swirl, with the result that the air and vapor, along with a small amount of liquid fuel, are forced through an orifice into the atmospheric chamber. Here the fuel comes to rest at atmospheric pressure. This allows the air and vapor to rise to the top portion of the chamber, where they leave the dispenser through a vent tube. The level of the liquid that remains in the bottom of the chamber rises until it raises the float, thereby opening a valve that allows it to leave the chamber and be drawn along a passageway back to the pump inlet.

At the same time, the main body of fuel, free of air and vapor, passes from the separating chamber to the automatic control valve. This valve is similar in design to the check valve we looked at earlier; it permits fuel to flow only in the direction of the meter, never back toward the pump. It also regulates the pressure of the fuel as it leaves the pumping unit and enters the meter, by closing when pressure on both sides has equalized (when the dispenser has been turned on but the nozzle remains closed, for example) preventing excess pressure from building in the meter and hose.

The control valve also has a built-in relief valve, which normally operates only when the dispenser is shut off. It relieves excess pressure caused by expansion of fuel on the discharge side of the valve by allowing a small amount to pass back through an orifice in the center of the control valve into the air separator chamber, where pressure can be relieved into the atmospheric chamber if necessary. The relief valve is very important, especially in warm-weather climates, because fuel expands when heated, and this expansion could raise pressure sufficiently to cause seals to fail, resulting in fuel leaks, or even burst the discharge hose if not relieved.

When the pump is operating (dispenser switch is in the "on" position) but the nozzle remains closed, the control valve will also close, as soon as pressure is equalized. The resulting increase in pressure in the separator chamber will open the bypass valve, permitting fuel to flow back to the pump inlet, thus relieving suction pressure and preventing additional fuel from being drawn from the storage tank.

In some self-contained systems, especially older ones, these components may be separate, and they may be referred to by different names. (For example, the atmospheric chamber of the self-contained unit, when separate, is usually called the sump.) But your basic knowledge of the interrelated functions of the pumping components should make it possible for you to recognize them, even when separated. In newer, larger fueling facilities the use of self-contained systems is declining. Currently less than ten percent of dispensers in new locations are self-contained. Remote pumping systems and remote dispensers explained in the following sections are more of today's norm.

Remote pump (or remote dispenser) Systems

In this type of system, fuel is pressurized and propelled toward the dispenser by a pumping unit located at or in the storage tank. The basic components of the pumping system are:

- a motor and pump assembly and discharge head,
- an emergency shut-off valve, located in each dispenser, and
- a control valve, also located at each dispenser.

In rare cases remote pumping systems employ a rotary vane pump like that used in self-contained systems, which sits atop the storage tank. However most remote systems employ a submerged pump. As its name suggests, the pump and motor assembly are completely submerged in the storage tank. As you can see in Figure 3-5, the pump—usually a multi-stage vertical turbine—is at the very bottom of the assembly. The intake of the submerged pump is located approximately four inches from the bottom of the storage tank to reduce the possibility of pumping water or sediment into the fuel system.

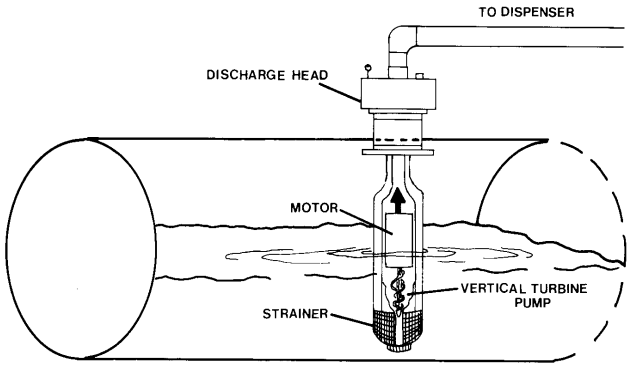


FIGURE 3-5. SUBMERGED PUMP AND DISCHARGE HEAD

Fuel is drawn into it through a metal strainer and flows from the turbine around the outside of the motor casing and through a section of pipe to the discharge manifold (head), which usually sits on top of the tank. The system check valve and the air eliminator are located inside the discharge head (manifold). The air eliminator functions in much the same way as its counterpart in a self-contained unit: air and vapor, along with a small quantity of fuel, are separated from the main body of fuel and drawn through an orifice. But in this type of system, the gases and fuel drain directly back into the storage tank; the tank itself functions as the atmospheric chamber or sump does in a self-contained unit.

In remote systems, several dispensers are often served by the same pump. When the on-off switch at any of these dispensers is placed in the on position, the pumping unit is activated, and all pipelines connected to the pump are pressurized (to 24-28 psi for a typical unit). To prevent the discharge nozzles of all the dispensers from being pressurized, each dispenser is equipped with its own control valve.

This control valve must not be confused with the control valve in a self-contained system: its design and function are quite different. The control valve in a remote system is not automatic: it is actuated by the dispenser's on-off switch, or is controlled by the electronic computer system. Figure 3-6 illustrates how a typical control valve works.

The control valve itself usually consists of a piston and cylinder (or diaphragm) and a spring, as shown in the cutaway drawing. A removable filter/strainer at the inlet to the valve (or at the fuel inlet to the dispenser) traps solid contaminants in the fuel flow before they enter the valve. When the piston is retracted, the valve is open and product flows through it toward the meter; when the piston is seated, product cannot pass through the valve.

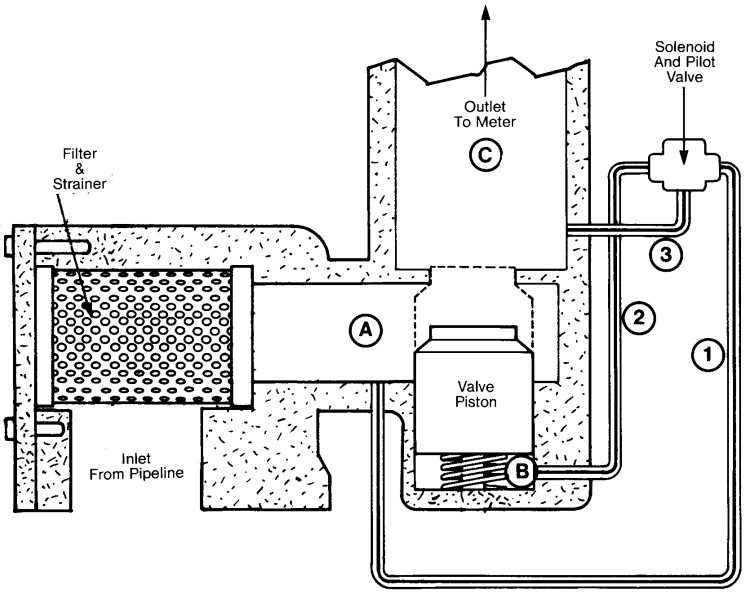


FIGURE 3-6. REMOTE-DISPENSER CONTROL VALVE

In older systems, the control valve may be operated mechanically, by means of a linkage between the valve and the dispenser on-off switch. Today, however, a more sophisticated electrical operator, including a solenoid and pilot valve, has been incorporated in most designs, as depicted in Figure 3-6. In some systems both the main valve and the pilot valve are incorporated into the same valve body. The device operates the valve by regulating the fluid pressure in the cylinder behind the piston or diaphragm (the area marked "B" in the drawing). When the dispenser is not being used (that is, the dispenser switch is in the "off" position), the solenoid is not energized and the pilot valve rests in such a position as to connect fluid lines (1) and (2). This maintains equal pressure on all sides of the valve piston, allowing the spring to keep the valve tightly closed.

When the dispenser switch is turned "on" or when the electronic computer sends power to the valve, the solenoid is energized, opening the pilot valve. This has the effect of opening a passageway between lines (2) and (3), and simultaneously closing off line (1). As long as the discharge nozzle remains closed, pressure remains the same in regions (A), (B), and (C), and the control valve remains closed. However, when the nozzle is opened, pressure at the outlet (C) falls, bleeding pressure from the space behind the cylinder (B). Pressure is now higher at (A) than at (B), and pressure on the head of the valve piston pushes it off its seat. When the dispenser is shut off, the solenoid is once again de-energized, closing the pilot valve and thereby shutting off the connection between (2) and (3) and opening the connection between (1) and (2). When pressure is once again equal at (A), (B), and (C), the spring (or diaphragm) forces the piston onto its seat, closing the valve.

The control valve prevents a remote dispenser from delivering product unless it has been switched on, and thus prevents accidental discharge under normal conditions. However, if a remote dispenser were to be struck with sufficient force, as might happen if a moving vehicle collided with it, even at relatively slow speed, piping in the dispenser could quite easily be ruptured. Since the fuel entering the dispenser is pressurized, this situation could cause fuel to flow uncontrollably from the ruptured pipe, creating an extreme safety hazard. To prevent this, every remote dispenser is equipped with an automatic emergency shut-off valve, also called an impact valve or shear valve because of its function, or a fire valve (as shown in Figure 3-7).

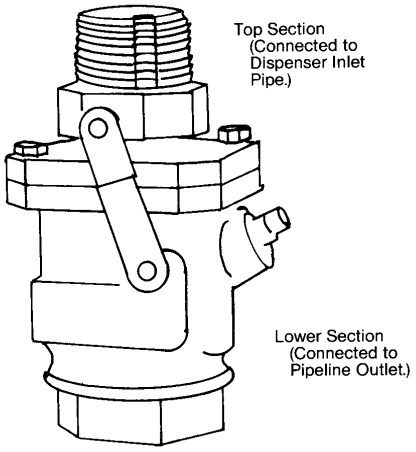


FIGURE 3-7. REMOTE SYSTEM EMERGENCY SHUT-OFF
(IMPACT OR FIRE) VALVE

This valve is located at the bottom of the dispenser, connected to the pipeline at the point where it enters the unit. The operation of this valve is very simple. In the event of damaging impact, the top portion of the valve shears away, isolating the damaged dispenser, and a spring valve automatically closes off the pipeline, preventing any further flow of fuel from that source. If it has not been too severely damaged by the collision, the control valve in the dispenser should then respond to the sudden drop in system pressure and close automatically, keeping fuel loss from the dispenser also to a minimum.

Self-contained systems do not require an emergency shut-off valve because fuel is pressurized inside the dispenser. So, a damaging collision will not result in uncontrolled flow from the storage tank pipeline, since suction pressure will cease immediately when a severe rupture occurs.

Blended-product Dispensers (Blenders)

The components that pressurize and move product in a blended-product system are essentially the same as those described above. However, the control valves in a blended-product system serve an additional function: they must be capable of controlling the volume flow rate of product, so that the blend will contain the correct proportions of component products. Such devices are commonly called metering or proportioning valves, and are somewhat more complex in operation than the basic on/off control valve described above. Blended-product dispensers have become more common in recent years and their proliferation is expected in the future due to environmental concerns with leaking underground storage tanks and associated piping. With blenders a retail outlet can provide three or more products to the consumer from only two underground storage tanks. Thus, the environmental hazard is reduced by having fewer underground tanks. Generally the blended product is delivered to the customer through a single product hose. When taking a sample for fuel quality (octane), special notice needs to be given to the flushing recommendations made in EPO 22.

Multi-product Dispensers

Prior discussion on pressurizing and moving fuel has concentrated on single and dual product dispensers. Many, if not most, dispensers used in fuel outlets today are of the multi-product design. Here three or more fuel products are available from a single dispenser. Usually only one product at a time is available for delivery

from each side of the dispenser. Like the blended-product dispenser only one computer is provided on each face of the multi-product dispenser. The multi-product dispenser may have a hose and nozzle assembly for each product, or there may be only one hose per dispenser side (face). In the case of the single hose multi-product dispenser the three (or more) product discharge lines are manifolded into one casting at or near the hose outlet fitting. Special notice should be made of the requirements in EPO 21 for flushing the line before taking samples for fuel quality (octane) testing.

METERING AND INDICATING FUEL DELIVERY, AND COMPUTING PRICE

Two major components are involved in metering and indicating the quantity of fuel delivered and computing the price of the delivery. In both self-contained and remote pump (or dispenser) systems, pressurized fuel flows from the pumping unit (self-contained systems) or control valve (remote systems) through a meter, which measures the fuel as it is being delivered. The meter is connected to the computer, which gets its name from one of its primary functions, that of computing the price of the delivery. In the case of mechanical, analog computing systems the meter is connected directly to, and drives, the computer through by mechanical linkage. In the case of electronic digital computers the computer receives its information in form of an electrical signal (pulse) from the pulsing mechanism (pulser) which is mechanically driven by the meter. The computer indicates the amount of product delivered, the price per gallon, and may perform other functions as well, as you will see. The meter is typically a mechanical device, but the computer may be mechanical, electronic, or both.

The Meter

Metering devices in most gasoline and diesel retail fuel-dispensing systems are positive-displacement meters, so called after the basic principle of their operation. In a positive displacement meter finite quantities of fuel are separated into compartments of known volume. These compartments may be cylinders within a piston meter, segments between two vanes in a vane type meter, or the space between rotors in other meters. The most popular type meter in retail fuel-dispensing systems is the piston meter. This discussion will concentrate on piston meter type of positive displacement meters.

A piston moving through a cylinder filled with liquid will displace a quantity of liquid ahead of it. The amount of this displacement is determined by the bore of the cylinder (its inside diameter) and the stroke of the piston (the maximum distance that it travels in one direction). The positive displacement method of metering is employed in fuel dispensers because it is capable of highly accurate measurement.

The meter itself consists of two or more (but usually no more than four) reciprocating pistons (each in its own cylinder), intake and outlet ports, and fluid channels. The pistons are connected to a crankshaft, or other stroke-regulating mechanism, so that one cylinder is discharging fuel during its piston's forward (discharge) stroke while another is being filled during the backward (intake) stroke of its piston. This provides a continuous flow of fuel through the meter. Figure 3-8 depicts meters from several manufacturers . In some piston type meters the pistons operate in the horizontal plane. In some systems the pistons are in the vertical plane and convert their to reciprocating action to a rotary shaft output to drive either the pulser or the mechanical computer.

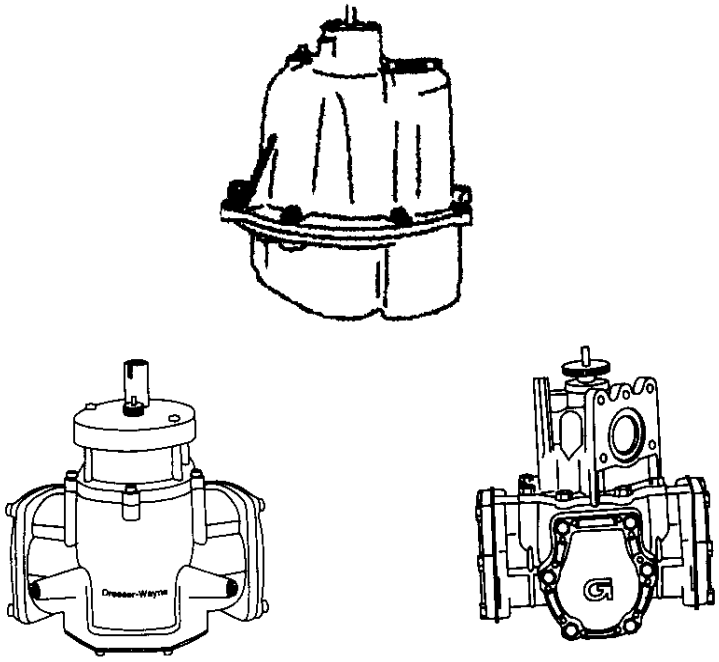


FIGURE 3-8. TYPICAL POSITIVE DISPLACEMENT METERS

The pistons are driven by fluid pressure supplied by the system pump. The cutouts on the piston heads function as valves, alternately opening and closing channels in such a way as to allow fuel to enter the cylinder during its intake stroke only from the inlet (pump side) and allowing it to exit the meter on the discharge stroke only through the meter outlet (nozzle side).

Other positive displacement metering concepts, as mentioned previously, are used, primarily for high speed dispensers in truck stop applications. In these metering systems a precise quantity of fuel is isolated between vanes or rotor blades in the metering chamber. The result is the same, highly accurate measurement is accomplished and the dynamic movement of the fuel converts the fluid motion to a rotary shaft motion to drive the computer, either mechanically or electronically.

The meter units are calibrated at the factory, and are designed to meter fuel accurately and reliably. However, recalibration will be necessary if the meter is found to be the source of over- or under-registration, so an adjustment mechanism is built into the unit. Adjustment may be accomplished by increasing or decreasing the throw of the pistons or by changing the size of the meter chamber. Changing the throw has the effect of increasing or decreasing the pistons' stroke, and thereby increasing or decreasing their displacement. These adjustments can be made in very small increments, changing the meter's discharge by as little as 1/3 cubic inch per 5 gallons indicated (or an average of less than 3/10,000 of a gallon per gallon indicated).

The adjusting mechanism may be located on the top of the meter or on one of the piston caps. It may be a knurled knob, keyed disk, or calibrated wheel (as in Figure 3-9), or have some different design. But it should be immediately identifiable by one feature: the adjusting mechanism must be designed to be protected with a security seal. This seal, if broken, may indicate someone has tampered with the meter, or has made a needed calibration adjustment. Without this assurance, an unscrupulous retailer could adjust the meter to deliver less

than a gallon for each gallon registered, and thereby charge customers for fuel that they are not actually receiving. So, as part of your inspection procedure, you will check this seal. With some of the high capacity systems, there may be no adjustment mechanism on the meter. In these cases the adjustment may be made electronically, you will need to refer to the Certificate of Conformance for the specific model to determine how to access the adjustment mechanism and the method of sealing used to protect the adjustment mechanism. Figure 3-10 shows the adjuster portion of several meters, which will be encountered in the course of field inspections.

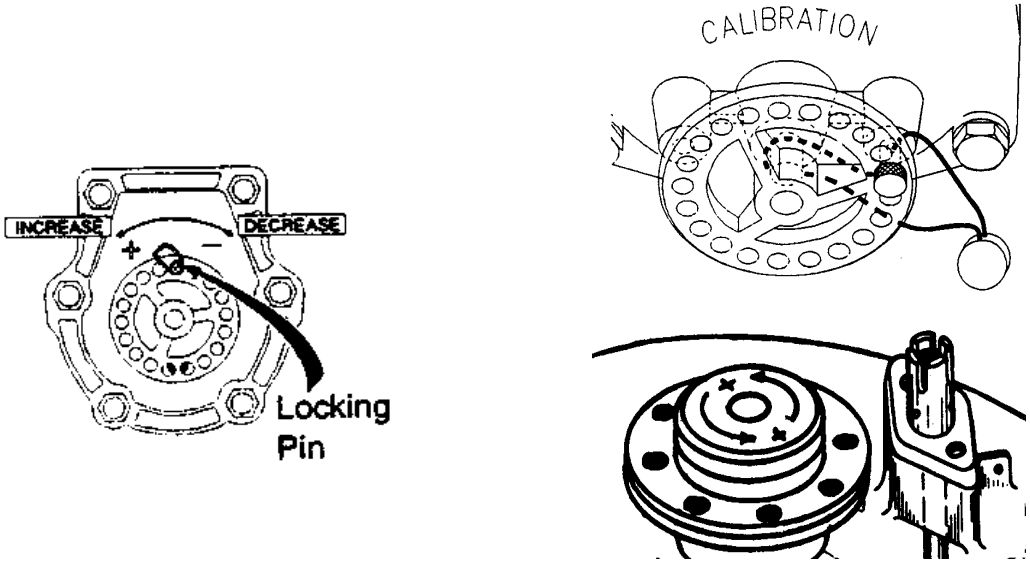


FIGURE 3-9. TYPICAL METER ADJUSTERS

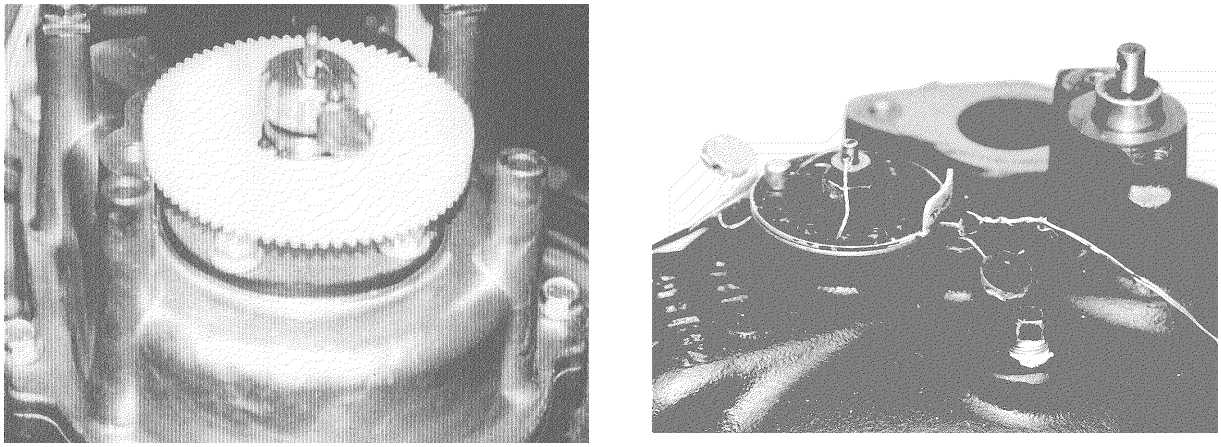


FIGURE 3-10. METER ADJUSTERS

The Computer

Each time the meter's crankshaft makes a complete revolution, an exact quantity of product has been metered. The quantity per revolution of the meter crankshaft varies from manufacturer to manufacturer, and with the meter design. So, the revolution of this shaft provides the most direct and accurate indication of the amount delivered. Whether the computer is mechanical or electronic, the computer or pulsing mechanism is driven directly—or through a universal coupling—by the meter shaft. Mechanical and electronic computers are quite different in design and operation, so we will take a brief look at each separately.

Mechanical Computers

Only a small percentage of new dispensers placed into service domestically have mechanical computers. Some of the dispenser manufacturers have discontinued mechanical dispensers as part of their product line.

What the motorist sees of a computer like the one shown in Figure 3-11 certainly does not look very complicated. Three sets of number wheels are visible: one set indicates the price of the delivery, another the amount delivered, and the third the price per gallon (unit price). Of these, of course, only the first two sets actually move during a delivery.

In fact, each computer has two identical groups of number wheels, one on each side, so that the attendant and the customer can see how much fuel is being delivered regardless of which side of the service island they are using.

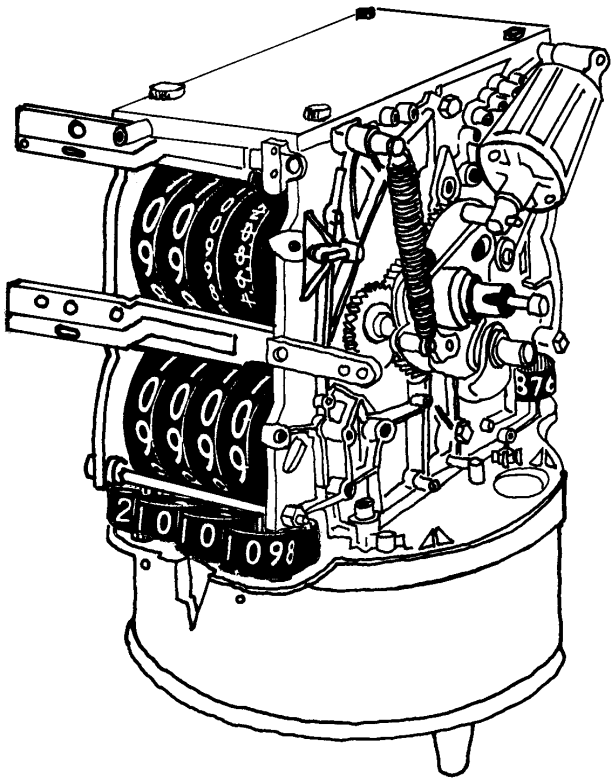


FIGURE 3-11. MECHANICAL COMPUTER

Each individual wheel turns independently, and the numbers inscribed on it represent one digit of a decimal number. For example, the wheel furthest to the right in the price set represents cents, the next number represents multiples of 10 cents, the next multiples of 100 cents (dollars), and so on. As the wheels revolve, a fixed pointer indicates the values.

What the motorist does not see, the "insides" of the computer, does not look at all simple: a multitude of gear wheels, drive shafts, chains, and spring mechanisms. The design is indeed complicated, as you might expect of a precision instrument, but the principle is really quite straightforward.

The mechanical fuel-dispensing computer is basically a clockwork mechanism. In fact, the computer is sometimes referred to as the clock, as according to a technical definition, it is. As in a mechanical grandfathers clock, trains of gears transmit and modify mechanical action in stages. A mechanical computer works in a very similar way: one gear train, deriving its movement originally from the meter crankshaft, will operate the 1/10th gallon wheel (compare the second hand in the grandfather clock). Another, deriving its movement from the same source, will operate the gallons wheel (compare the clock's minute hand). And so on.

This is how the computer operates both price and volume wheels. However, there is an additional element in the price computation, because—as we all know the price of fuel changes frequently. So the system of gear trains for the price wheels must be variable: otherwise, the station owner would have to install a new computer each time prices changed! This is accomplished by a component called the variator, which is usually located in the bottom portion of the computer assembly. The variator consists of a cone gear and a series of range arms, one for each price number wheel.

The cone gear is actually nine separate gears, one for each decimal value from 1 to 9. All nine revolve at the same rate—usually that of the meter crankshaft. A single gear on the range arm can be raised or lowered to key to any one of the gears in the cone. Changing the gear to which the range arm gear is keyed will result in a higher or lower gear ratio, so the range gear will revolve more or fewer times for each rotation of the cone gear shaft, and this rate will be transmitted by the range shafts to the gear trains that operate the price number wheels. The range shaft is also connected directly to the price-per-gallon wheels, so that when a change in price is made by raising or lowering one or more of the range arms, that change will be indicated automatically.

The volume and price indicator wheels must be reset to zero before each delivery. We will discuss this function later. But in addition to the indicators that the motorist sees, the computer also operates sale and volume totalizers. These are not automatically reset between deliveries. So the totalizers, as their name suggests, indicate running totals, which are useful for inventory control, and also protect the station owner from theft by employees, since sales totals can be expected to match sales receipts. The totalizers are required to be nonresettable. Some manual reset mechanisms may be sealed so that tampering can not be done without mutilating the seal and, thus, leaving detectable evidence. Again, this is to protect the owner, since totalizers are generally not used as indicators for individual sales.

Electronic Computers

As you know, the modular design of most electronic systems permits the incorporation of a variety of extended functions, so their functional capabilities usually are considerably more extensive than those of mechanical systems: they go beyond simply indicating the quantity of fuel delivered and computing and indicating its price, as mechanical computers generally do not. We will discuss some of these extended features later in this chapter. For now, though, let us simply consider the functions that correspond to those of a mechanical computer.

Understanding the technical details of electronic systems requires some knowledge of various high-technology components—integrated circuits, microprocessors, logic components, interfaces, and so on. Presenting this basic knowledge is beyond the scope of this course. So keep in mind that our discussion will be focusing on a functional description. The basic functional components we are concerned with are illustrated in Figure 3-12.

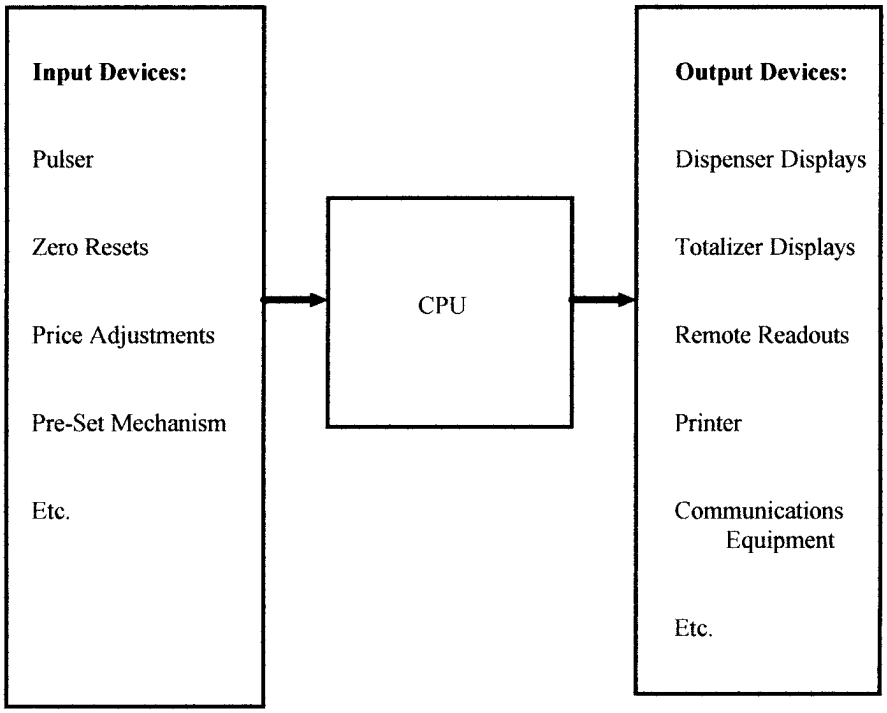


FIGURE 3-12. FUNCTIONAL COMPONENTS OF AN ELECTRONIC FUEL DISPENSING COMPUTER

The transducer (or pulser, as it is commonly called) is coupled directly to the meter shaft, just as in a mechanical computer. The function of the pulser is to transform the mechanical action of the revolving shaft into digital signals. It does this by generating a fixed number of discrete electrical pulses per revolution of the meter shaft. (A discrete number of pulses are generated per gallon delivered; while several dispenser manufacturers use 1000 pulses per gallon, or 250 pulses per revolution of the meter shaft, that is not so with all systems.)

The pulser is essentially a switch, which is actuated periodically by the meter shaft (usually via a gear train). The terminals of the switch are connected to an external power source. Each time the switch is closed, voltage is applied; when the switch is open, voltage ceases to be applied. In most systems the low voltage pulse is generated by a metallic element making and breaking a magnetic field. In some cases the magnets are imbedded in a disc and the magnet poles rotating in front of a sensor generate the electrical pulse. The result, diagramed in Figure 3-13, is a single discrete pulse.

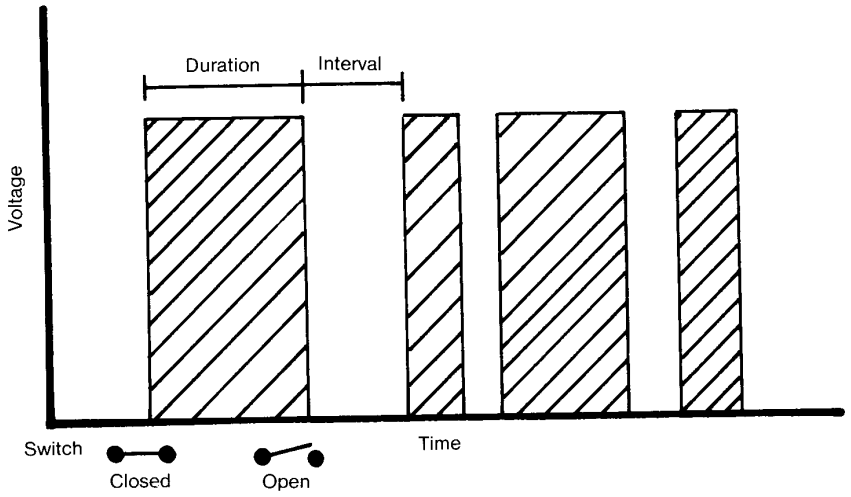


FIGURE 3-13. GENERATING DISCRETE PULSES

The duration of individual pulses created in this way, and the intervals between them will vary with the rate of rotation of the meter shaft, but their value (voltage) will be the same and, for the duration of each pulse, constant.

These pulses are transmitted as input to the central processing unit (CPU). The first thing the CPU must do is recognize the pulses as signals from the pulser and not from another input device; as Figure 3-12 illustrates, even a very simple system like the one we are looking at has various sources of input (zero reset devices for the totalizer and pulser, and the price-per-gallon adjustment device), and these must be distinguished from one another so that they can be processed correctly. So the CPU checks the characteristics of the incoming signal against information stored in its memory. Once it has determined that the source of the signals is the pulser, the CPU is able to process the information, "counting" the discrete pulses and computing the volume being delivered and its price with each pulse received. Again, its memory provides the necessary information for these computations (pulses per gallon, price per gallon, number of pulses already received, accumulated price).

The final step for the CPU is to convert the "results" of its computations into signals that will actuate the indicating devices, usually light-emitting diodes (LEDs) or liquid crystal displays (LCDs). This output is transmitted to the appropriate indicator (dispenser price/volume indicator or totalizer) where the display is generated automatically.

This all may seem complicated and even cumbersome when compared with the relatively simple clockwork operation of a mechanical computer. But remember that the functions we have just considered can be performed by the electronic computer virtually instantaneously, employing very few moving parts (only in the pulser), and with great accuracy and reliability. At the beginning of this section, it was said that computers can be both mechanical and electronic. This is often the case when an older system is adapted for use with an electronic control console or other electronic devices.

Usually this involves linking a pulser to one of the shafts of the existing mechanical computer (for example, the one-cent wheel shaft). The important thing to keep in mind when inspecting such a device is that the dispenser

indicator is an analog device while the console readout is a digital device. Handbook 44 includes special guidelines for inspecting such installations.

CONTROLLING THE OPERATION OF THE FUEL-DISPENSING SYSTEM

All of the components of a fuel-dispensing system we have discussed so far in this chapter operate automatically or like the remote dispenser control valve—are activated by other components during fuel deliveries. Of course, many of these components are adjustable, like the meter and computer, but these adjustments are not part of the operating function of the dispenser, and are normally made while the dispenser is shut down.

Operating a gasoline pump is one of the few truly simple procedures that most of us have to master in our adult lifetimes. One reason for this is that there are relatively few controls to manipulate, and these master controls are operated in a definite and invariable sequence. We will conclude this chapter with a look at these system controls—some of which are not as simple as they may seem.

The Discharge Nozzle

The customer receives exactly the quantity of fuel he or she wishes to purchase from a properly installed and adjusted fuel-dispensing system. Yet the customer does not receive all of the fuel that has passed through the meter between the time when the dispenser was switched on and the time when it was switched off. These two statements seem contradictory, but they are really not, and this puzzle—if you have not already guessed the solution—provides a good introduction to one of the fuel-dispensing system's primary control devices, the discharge nozzle.

To summarize, the discharge nozzle performs three basic control functions. It:

- controls fuel delivery,
- prevents vehicle tank over-fill (when the nozzle is so-equipped), and
- prevents the discharge hose from draining after completion of a delivery.

Additionally the nozzle may be equipped with mechanisms which prevent flow of fuel unless the nozzle is inserted into the fuel filler pipe of the automobile. Some nozzles are equipped with pressure sensitive devices which prevent the main poppet valve of the nozzle from opening unless the fuel system is pressurized. In pre-pay situations nozzles are sometimes replaced into their holders with the nozzle lever still cocked or in the open position. This feature causes the nozzle poppet to close when the dispenser is turned off and will not allow flow until the system is again pressurized (by turning the dispenser on) and the nozzle lever released and then reopened.

Of these three functions, the last two are fully automatic, and require no action on the part of the operator (either the station attendant or the self-service customer). However, the nozzle outlet valve (see Figure 3-14) must be opened before fuel can flow into the customer's vehicle. In fact, fuel does not flow through any part of the system (except the self-contained air eliminator and by-pass circuit and the submersible pump riser tube and air eliminator) until the discharge nozzle is open. The operation of the nozzle outlet valve, by means of the control lever, causes fuel to flow—or cease flowing through the entire system; it also regulates the rate of delivery, so the valve must have a continuous range of openings.

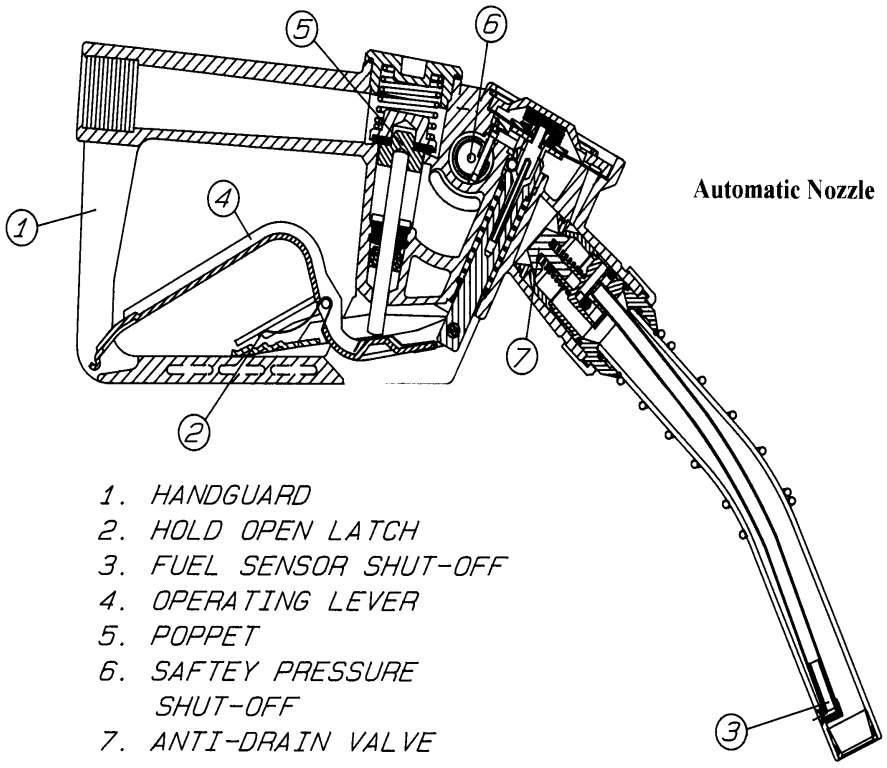


FIGURE 3-14. DISCHARGE NOZZLE

In most locations retail dispensers are required to be equipped with automatic shut-off devices, which prevent fuel from being delivered once the vehicle tank is full, thus reducing the risk of over-flow and resulting spillage, which is always hazardous.

There are several different designs of automatic shut-offs in common use. One design (shown in Figure 3-14) incorporates a small air tube, called a venturi, which runs down the length of the nozzle. The shut-off mechanism is designed to "breathe" through this tube. As long as air can pass through the tube, the delivery is regulated only by the outlet valve. But when the entrance to this tube is blocked—by touching liquid fuel, or anything else—even momentarily, the shut-off mechanism automatically trips the outlet valve shut, preventing delivery until the venturi is again unobstructed.

When the discharge nozzle is opened at the beginning of a delivery, fuel flows from the nozzle outlet immediately. This is because the discharge hose, like the rest of the dispensing system, is filled with liquid fuel at all times. (For this reason, retail motor-fuel dispensers are referred to as "wet" hose devices.)

Here, of course, is the answer to the puzzle that introduced this section: the fuel that fills the hose at the beginning of a delivery actually passed through the meter during the previous delivery. The assurance that the customer always receives exactly the quantity of fuel he or she is paying for is the principle of displacement. Fuel metered during a delivery will initially displace exactly the quantity contained in the discharge hose.

Fuel usually flows with gravity through at least part of the discharge hose. So, in order to keep the hose full at all times, and assure accurate deliveries, the nozzle must have some means of preventing fuel from being drained from the hose after the dispenser has been shut off. If this was not done, one customer might receive more fuel than he or she has paid for by draining some of the fuel in the hose, while the next customer could receive less than he or she has paid for, because at the beginning of the delivery, fuel flowing through the meter is displacing air, not liquid fuel.

The device that prevents this is called the antidrain means. In retail systems its operation is automatic. It works by permitting fuel to flow only while the system is pressurized by the pump. Many newer nozzles will not allow the main poppet to open unless the system is pressurized by the pump.

The pressure-regulating valves in the pumping unit (or control valve in a remote system) will maintain stable pressure as long as the dispenser is turned on. System pressure drops immediately when the dispenser is turned off, and this drop in pressure activates the antidrain means, preventing further delivery or draining of fuel from the nozzle and hose.

As mentioned in the last chapter, many States now require that gasoline pumps be equipped with vapor recovery systems. Over the past few years there has been a proliferation of states or local jurisdictions requiring vapor recovery. Use of these systems is expected to grow in the future. Since the design and operation of the discharge nozzle is substantially affected by the incorporation of vapor recovery, this is an appropriate place to describe this feature briefly.

Technology in vapor recovery equipment is expanding as rapidly, keeping pace with the expanding requirements for use of vapor recovery. At one time the most apparent component of the balanced vapor recovery system was the "boot," a semi-rigid corrugated tube that surrounds all but the very tip of the discharge spout. In order to pump gas, the end of the nozzle must be pushed firmly into the vehicle fill pipe and held in this position, so that the boot is compressed, with its lower end seated tightly against the rim of the fill pipe, as shown in Figure 3-15a. Additionally Figure 3-15b gives more detail of the internal parts of a balanced system vapor recovery nozzle. If insufficient pressure is applied, or if the seal is broken, the automatic shutoff mechanism remains disengaged, and the nozzle can not be operated.

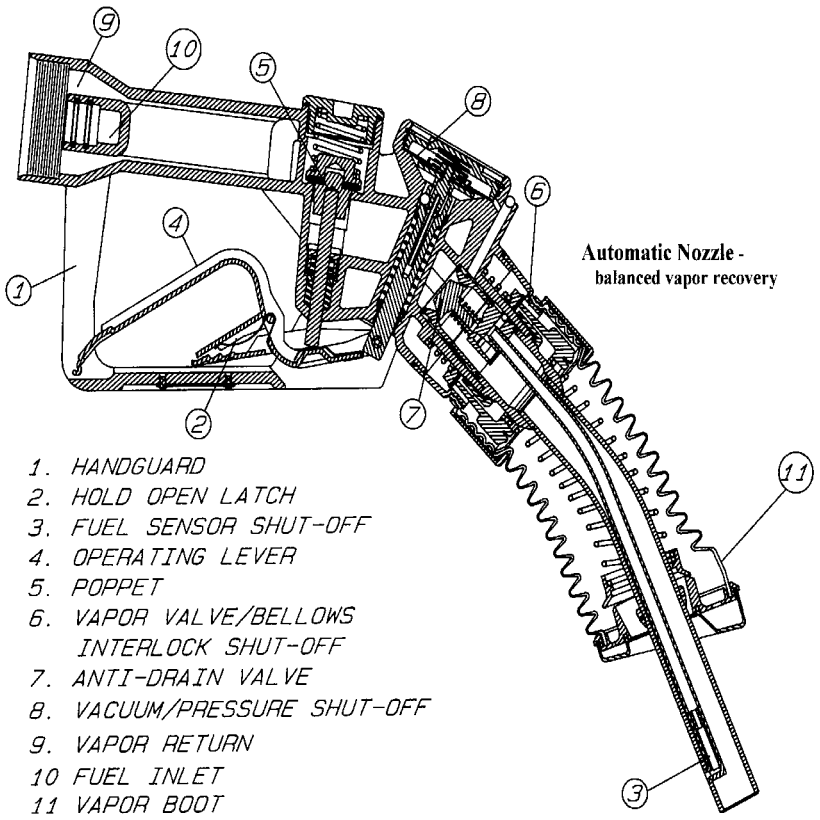


FIGURE 3-15a. VAPOR RECOVERY NOZZLE

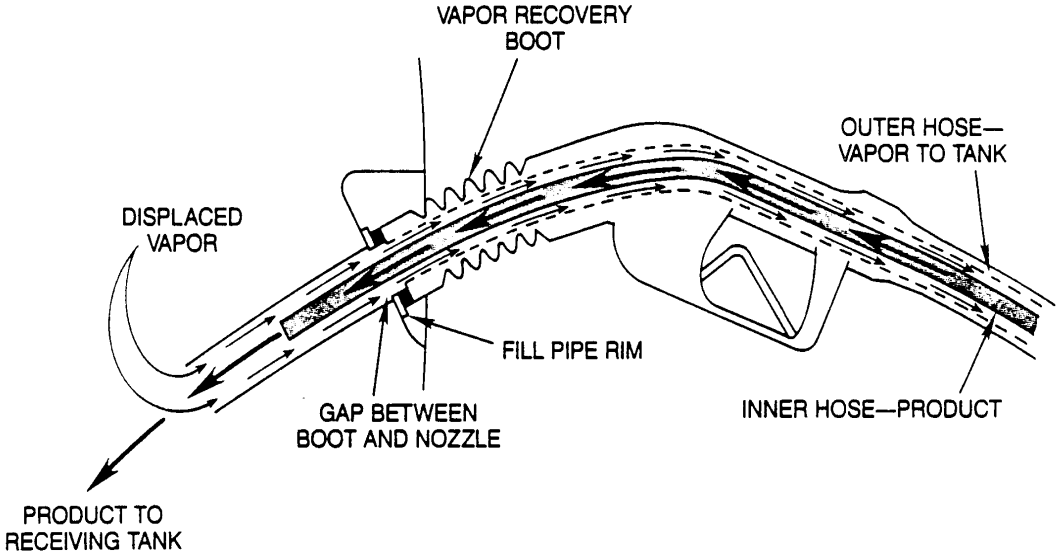


FIGURE 3-15b. VAPOR RECOVERY NOZZLE

As can be seen in Figure 3-15a, when product is being delivered, air and vapor inside the receiving tank, which are displaced by the rising liquid level, pass up the fill pipe and through the clearance between the boot and the discharge spout (this clearance is only open when the boot is compressed). The vapor is kept separate from the liquid flow inside the nozzle, and enters a hose at the dispenser end, which leads back to the air space of the facility's product storage tank for that product.

Since product is being drained from the storage tank at the same rate as vapor is discharged from the receiving tank, pressure is continuously equalized, and because the system remains closed, vapor does not escape to the atmosphere. Most vapor recovery systems now incorporate a concentric "hose-within-a hose" design, like that shown in Figure 3-17, with the product hose running inside the vapor hose. This makes the hose less unwieldy. With the balance system the outer of the two hoses is the vapor return line and the inter hose the fuel line.

More recently introduced into the market place are systems which have vacuum assist. A vacuum pump or venturi within the system develops a vacuum which helps to "pull" the gasoline vapors from the automobile's fuel tank and "push" them into the underground storage tank. Some of these systems have a boot which is much smaller than the balanced system boot as shown in Figure 3-16a. In these systems there is not a requirement for the seal at the interface of the nozzle bellows and the automobile fill pipe as with the balance system. Here the bellows end serves more as a funnel to direct the vapors into the nozzle, and thus back to the underground tank.

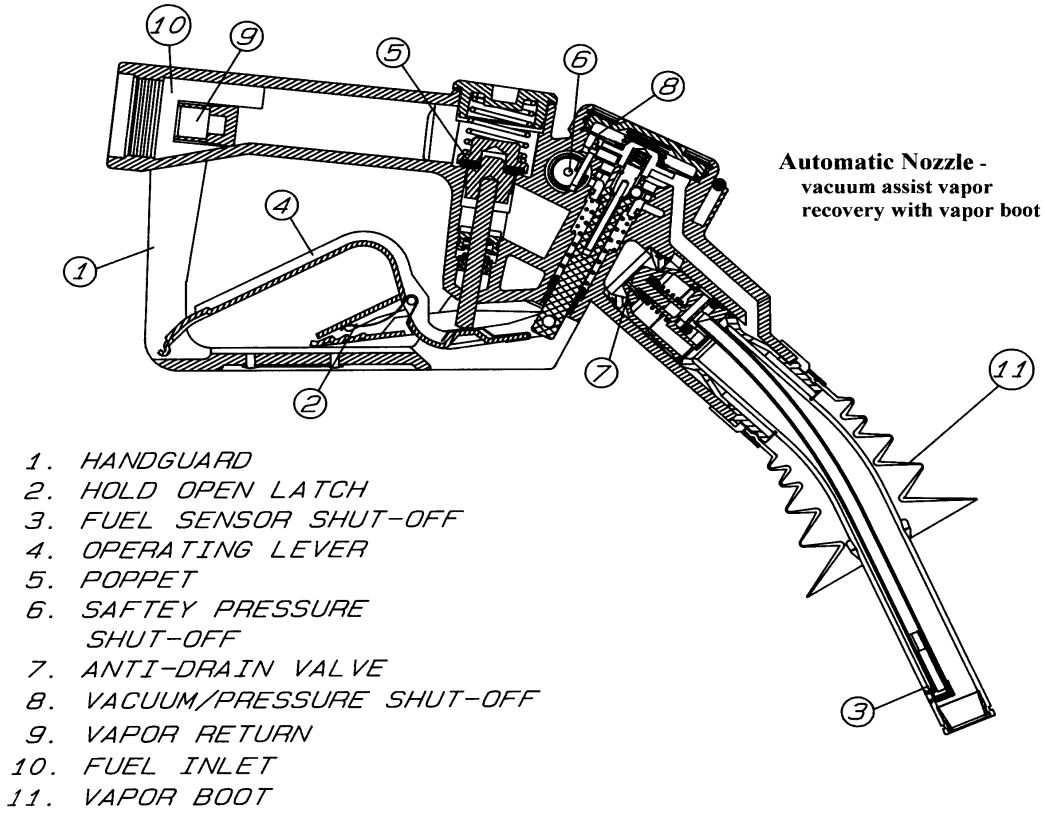


FIGURE 3-16a. VACUUM ASSIST VAPOR RECOVERY NOZZLES (WITH BOOT)

Still other nozzles used in vacuum assist systems have no boot as shown in Figure 3-16b. In these systems the vapor is drawn from the automobile fill pipe through small holes near the nozzle tip. Vacuum assist nozzles of this type are hardly distinguishable from a conventional automatic shutoff nozzle. The hose is slightly larger than a conventional hose since it must contain both vapor and fuel hoses in a coaxial arrangement. With

vacuum assist systems, since there is an "assist" to get the vapors to the underground tank, the vapor line generally is the smaller inter hose. Fuel flows through the outer hose in the concentric hose design. This arrangement allows for a smaller hose than the balanced system hose.

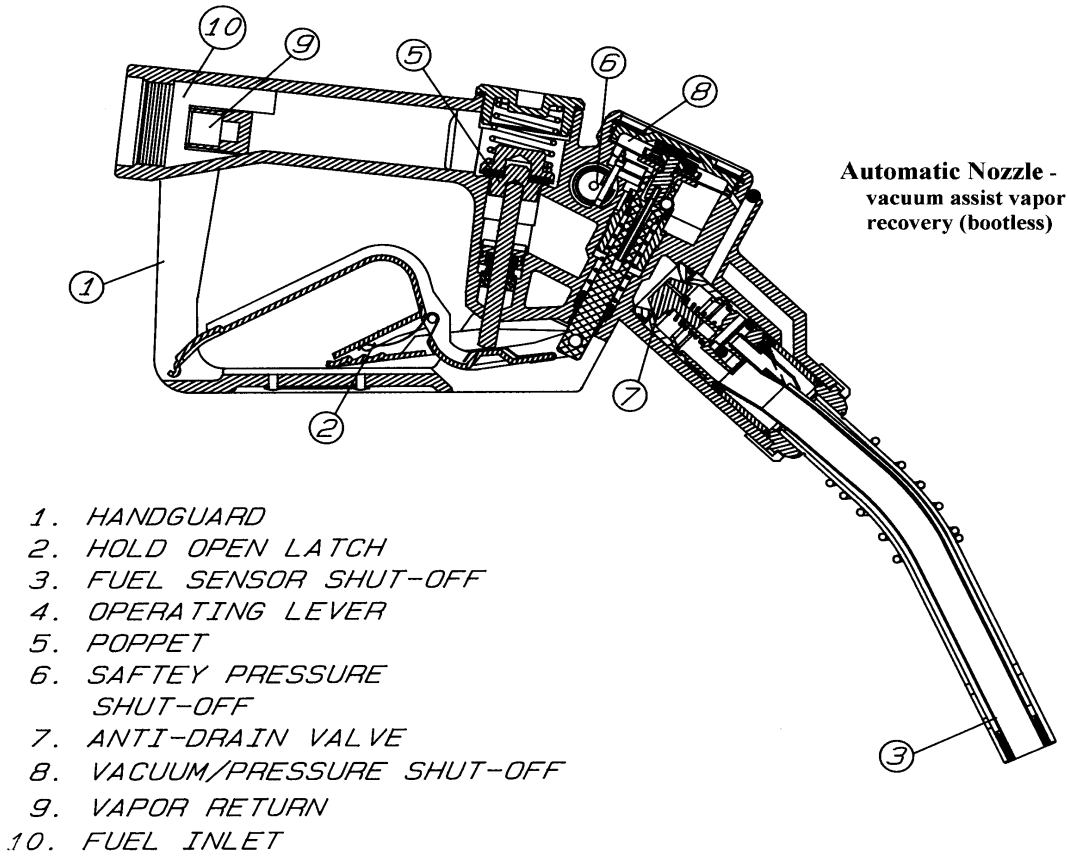


FIGURE 3-16b. VACUUM ASSIST VAPOR RECOVERY NOZZLES (BOOTLESS)

The vapor recovery system is quite effective in reducing vapor emission during delivery. However, the weights and measures inspector must be aware of factors that can affect measurement accuracy during testing. One of these is the tendency for some product to become trapped inside the boot or within the vapor return portion of the hose at the end of a delivery, especially if the operator attempts repeatedly to over-fill (top-off) the tank. Although the amount of liquid trapped after any single delivery is likely to be small, it can accumulate in the boot and back into the vapor recovery hose. When the nozzle is held in a nearly vertical position (as it is when filling a test measure) the trapped liquid will drain from boot and/or hose. It is therefore recommended that when testing vapor recovery equipment any trapped liquid be carefully drained before commencing a test draft (for procedure, see Chapter 4).

Figure 3-17 shows two types of hose used with vapor recovery systems. The larger hose on the left is used in balanced vapor recovery systems, where the larger outside hose is the vapor hose. The smaller hose on the right is used in assist vapor recovery systems. In these systems the vapor hose is the smaller inside hose.

FIGURE 3-17. VAPOR RECOVERY HOSE SYSTEMS

Other Manual Controls

When the dispenser is turned on, two things happen:

- The dispenser's computer is reset to zero.
- The system pump is activated, in a self-contained dispenser; in remote systems, power is applied to the submersible pump, and the control valve is opened (a short delay, 2-4 seconds, may be experienced between the time the pump started and the valve is opened).

The sequence must happen in this order to assure accurate measurement and indication of quantity and price. Systems vary widely in the method used to perform the dual function to reset the computer and start fuel flow. For mechanical computer systems and some electronic computer systems the nozzle is lifted from its normal hanging position and the on-off lever (as Figure 3-18) is rotated or lifted to cause these functions.

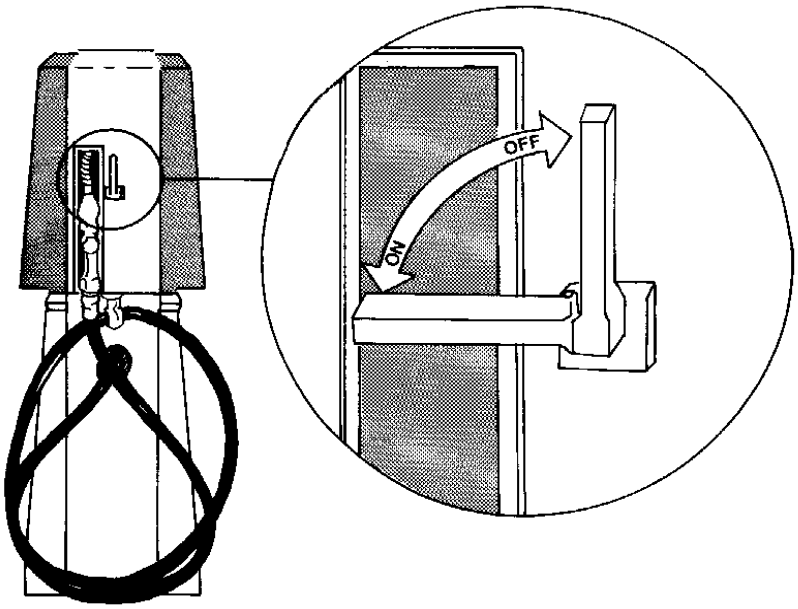


FIGURE 3-18 DISPENSER CONTROL LEVER

Many electronic systems use selection of a grade, price, or pressing a "push to start" button or icon to perform the start function. Safety regulations prohibit lifting of the nozzle from being the only action required to set the pump or dispenser into its fuel delivery mode. Regardless of the operating method, the dispenser computer is reset to zero and then pumps are turned on and valves opened to allow fuel delivery from the nozzle.

In some systems, the pump control switch and zero reset are operated by separate controls. In this case, an interlocking device prevents the pump control switch from being activated first. This design is most common in self-service facilities, with the zero reset operable only by means of a key held by the attendant. This feature prevents unsupervised self-service deliveries.

Dispensers are designed in such a way that the nozzle cannot be reinserted in its hanger until the on-off control has been returned to the off position. This feature is intended to prevent a dispenser from being inadvertently left on after a delivery has been completed, permitting the dispenser to be used again before the computer has been reset. In some cases merely replacing the nozzle into the nozzle receptacle (boot) performs the action to shut-off the dispenser. A shut-off switch linked to a "flap" within the nozzle boot deactivates the dispenser when the nozzle tip strikes the "flap." Some dispensers with the flap type actuators also have a stop button located on the face of the dispenser, either pushing the stop button or replacing the nozzle will deactivate the dispenser. Some systems require that the start-stop lever be rotated to the off position (as discussed previously) or part of the nozzle hanger mechanism to be pushed downward to shut the device off and allow replacement of the nozzle.

Service, Payment, and Product Selector Controls

Until the mid 1980s, the only controls on most gas pumps were the on/off control lever and the discharge nozzle control lever; all other operations were automatic. However, advances in technology, especially in the area of electronic computers, and new marketing strategies—including self-service, blending, single hose multi-product dispensers, multi level pricing, and card readers or cash acceptors in the dispenser or on the island—have given the consumer choices to make. This variety of choices and operating characteristics also make the task of pumping gas somewhat more complicated.

The late 1980s and early 1990s brought a surge of multi-tier pricing—discount for cash, cash/credit, and full-serve/self-serve. With the exception of full-serve/self-serve, the other multi level pricing marketing strategies have pretty much gone by the way side. In most installations full-serve/self-serve are handled with dedicated islands according to the type of service. Seldom are both offered through the same dispenser.

In most cases selection of the cash or credit payment mode, <u>today</u>, relates to "in pump" cash and/or card acceptors and has no impact on the price the consumer pays for the product. The few facilities that offer discount for cash (cash/credit) generally have controls on the dispenser for selection of the payment method. An example of such a dispenser is shown in Figure 3-19.

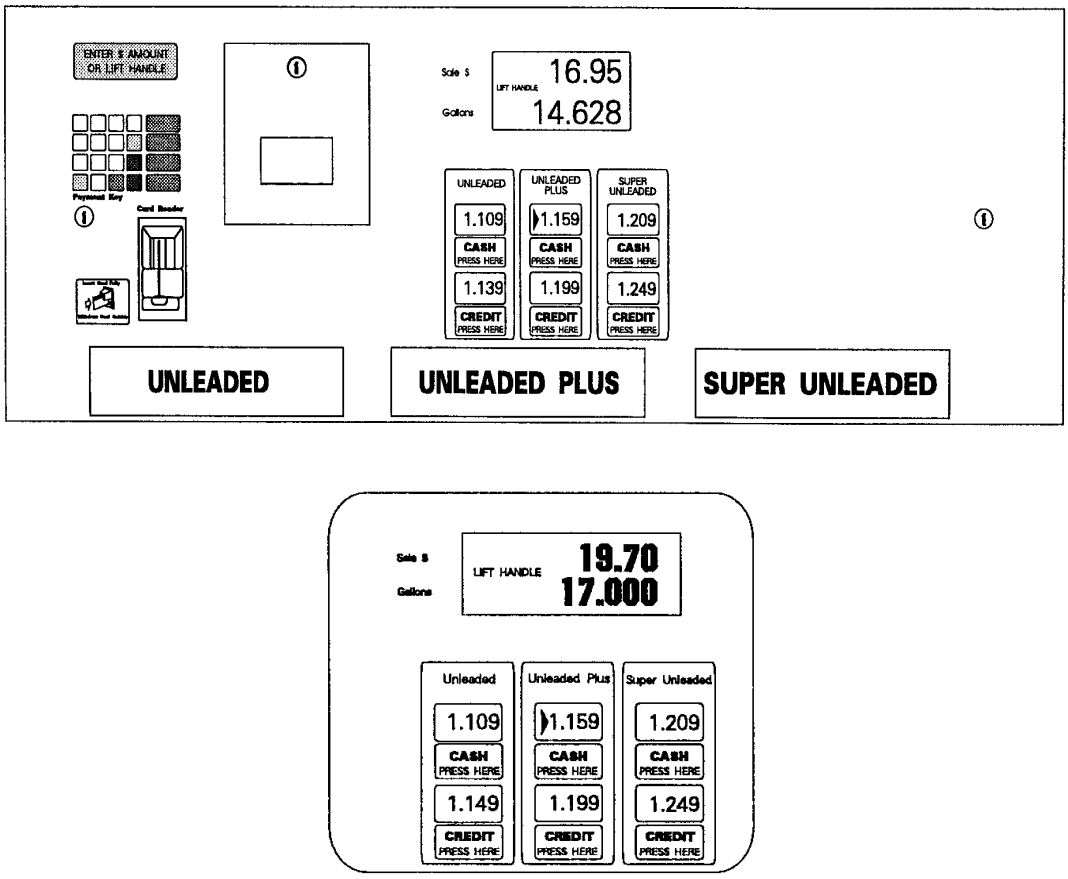


FIGURE 3-19. MULTI-PRICING DISPENSER

In 1988, the National Conference on Weights and Measures adopted the policy that "the use of a single-price-computing dispenser for sale of motor fuel at multiple unit prices is inappropriate, facilitates fraud, and should be eliminated." As you will learn in Chapter 5, nonretroactive changes were later made to Handbook 44 in support of this policy.

The cash and credit unit prices for each product offered at this multi-product dispenser are displayed beneath the markings that identify the product dispensed from each hose (premium unleaded, etc.). As the instructions in the upper left corner of the display panel indicate, the operator first selects the method of payment by pressing either the cash or credit pushbutton. When the product is selected, by raising the nozzle rest (the control lever

on this dispenser), the price-per-gallon display for the current sale (on the right hand side of the panel in this example) is automatically updated to display the selected price for the selected product. For example, if "credit" and "unleaded plus" were selected, this dispenser would display a price per gallon of $1.149. The computer would also be set automatically to compute the total sale at the selected price per gallon.

Equipment like that shown in Figure 3-19 could be adapted to provide multi-tier pricing and computing capability for an additional type of service (full- or self-serve). This would require the display of twice as many unit prices, and additional selector buttons. Or, a more likely scenario is that manufacturers would probably design equipment to "scroll" the unit price for the various modes since Handbook 44 does not require all the unit prices to be simultaneously displayed.

As described in the last chapter, blended-product dispensers are capable of delivering several different products from the same dispenser. In the case of multi-hose blended-product dispensers, like the one shown in Figures 3-19 and 2-11, the operator selects the desired product by operating the control lever for the corresponding hose (which is marked to indicate the product dispensed). For single-nozzle blended-product dispensers, the operator usually selects the product by means of a separate control on the dispenser (selector dial, pushbuttons, etc.). When this is done, the computer and display are automatically updated for the unit price of the selected product.

As you will learn shortly, Handbook 44 includes a number of regulations relating specifically to selector type controls and multi-pricing displays. These regulations are intended to minimize confusion for the customer and discourage abuse or fraud by the owners or operators of such sophisticated fuel-dispensing equipment.

Electronic Control Consoles

Electronic control consoles and point of sale (cash registers) systems are being installed in more and more fueling facilities, because of the popularity of self-service, and because of the many additional features and efficiency they provide. The modern console is more than a display that duplicates the current sale information on the dispenser. It is a valuable business tool which aides in inventory control, shift performance, and the like.

As was the case with electronic computers, we can only undertake a simplified, functional description in this course. However, you should also have some familiarity with the basic "external" features of these devices, since remote consoles are, at least in part, indicating devices, and so must be checked in the course of your inspection.

You will recall from our discussion of electronic computers that two types of devices were linked to the CPU: input devices (the pulser, price adjustment, zero resets) and output devices (dispenser and totalizer displays). Control consoles incorporate functions of both input and output devices, as illustrated in Figure 3-20 on the following page.

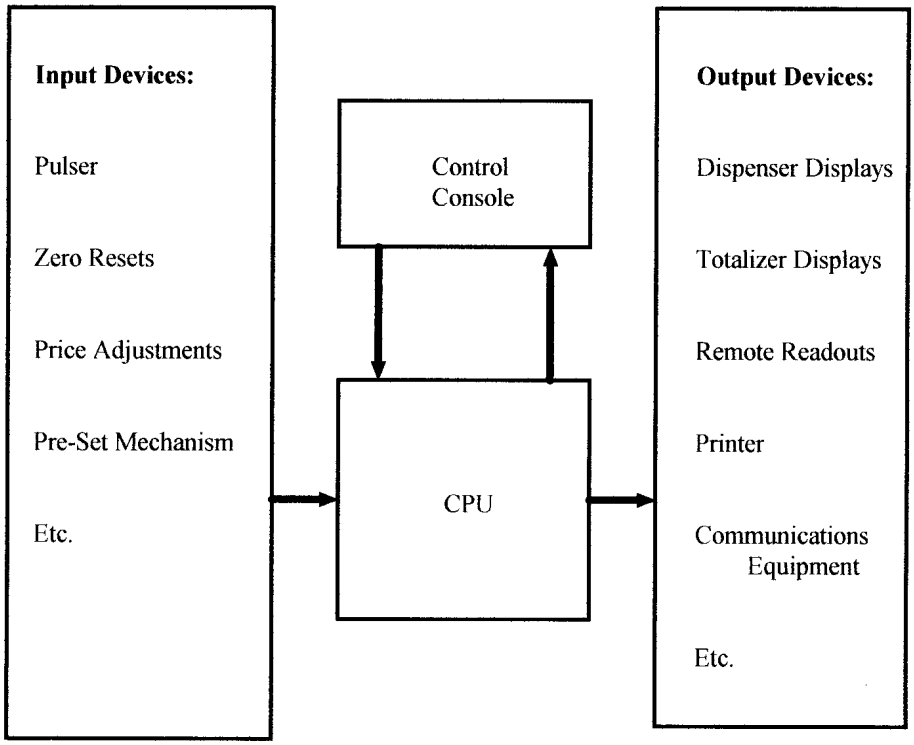


FIGURE 3-20. CONTROL CONSOLE AS A FUNCTIONAL ELEMENT

As output devices, they:

- show the status of each dispenser (on or off);
- provide readouts of the same delivery information (quantities delivered, price and price per gallon) as shown on the dispenser; and
- display sale/transaction information sent as input to the CPU, and the results of any computations made (e.g., change due, credit OK).

As input devices, control consoles may be used:

- to pre-set the quantities or total price of fuel to be delivered (pre-pay);
- to control individual dispensers, allowing deliveries only upon "authorization" by the console operator;
- to provide emergency shut-off control for one or all dispensers;
- as a cash register (point of sale terminal), to enter non-fuel purchases and payment received;
- to transmit credit card numbers for verification and authorization; or
- to program the CPU (to change the price per gallon, or to collect, process, and store or communicate data from other input devices).

The external features of the control console are its displays, keypad, and control buttons. To get a better sense of these "external" features, let us take a look at a typical control console, like the one shown in Figure 3-21.

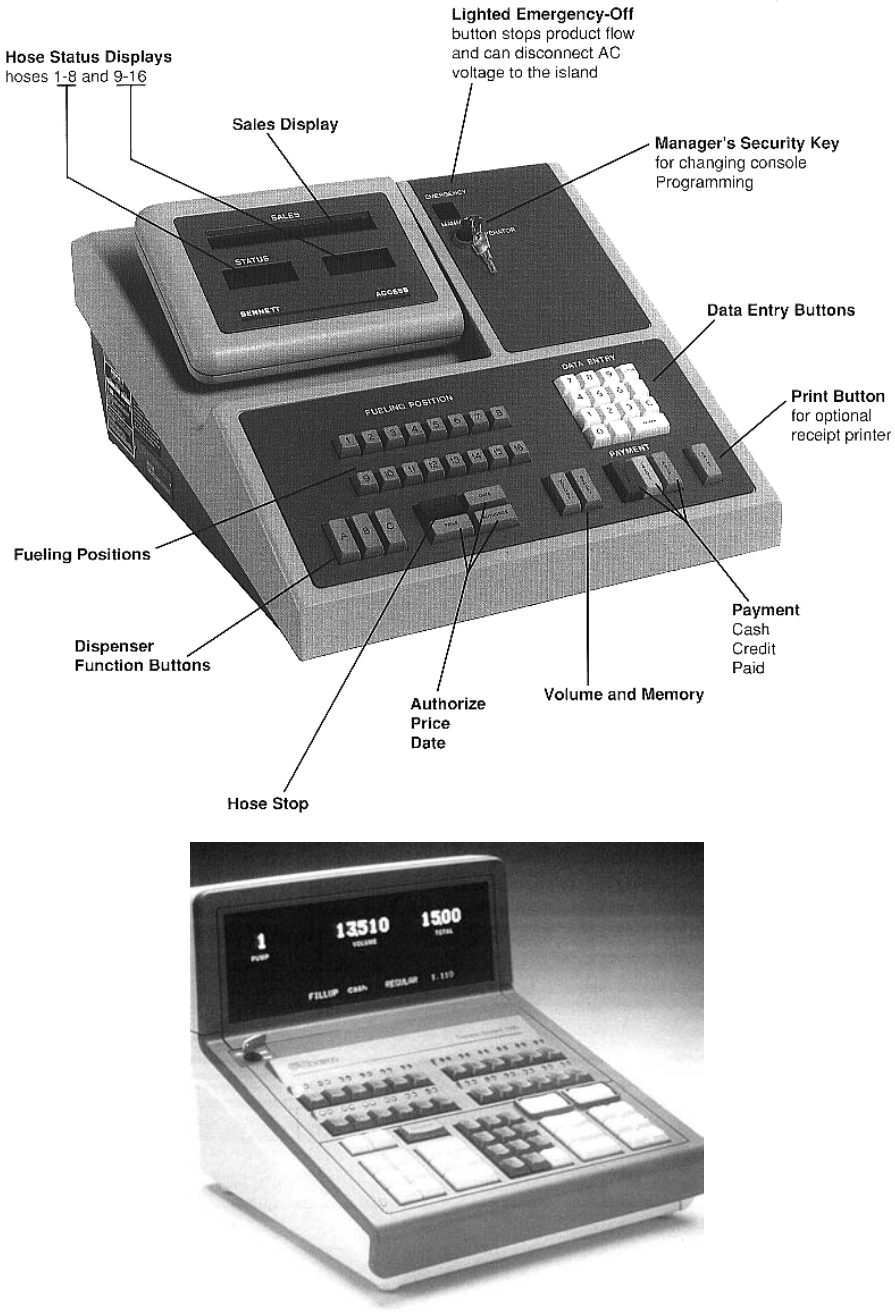


FIGURE 3-21. FEATURES OF TYPICAL CONTROL CONSOLES

As you can see, the display area placement varies with different manufacturers, but generally the consoles have similar display and keyboard layouts. The upper area displays volume, price, and price per gallon, and also a numerical identification of the dispenser (hose) for which this delivery information is being displayed. The lower display shows the status of each dispenser. Information for these displays is "called up" by depressing

one of the dispenser identity buttons (there are 12 on this model) These two displays represent the output device functions of the control console.

The keypad in the center provides the operator with the means of entering information or commands from the console in a variety of "modes."

The buttons on the right of the keypad are used to send information to the CPU, while the buttons on the left are used to send particular commands, via the CPU, to the individual dispensers (authorizing them or halting them), or to request transmission of data to another output device (a printer). In addition, an emergency switch controls the entire dispensing system.

The console is designed in this way to facilitate the monitoring and control of the operation of an entire fuel-dispensing system by a single operator.

SUMMARY

A number of separate elements work together to assure the safe, efficient, and accurate operation of a retail motor-fuel dispensing system. Because of their functional interdependence, the failure or malfunction of one element can inhibit the effectiveness of others and impair the correct operation of the entire system. Specific requirements relating to the selection, installation, maintenance, and use of these elements are described in detail in Chapters 5 and 6.

CHAPTER 4

TEST EQUIPMENT AND SAFETY PROCEDURES

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Identify the equipment used in testing retail motor-fuel dispensing systems.
2. Identify procedures for the use and care of test equipment.
3. Describe the proper steps to perform a liquid-measuring accuracy test using a 5-gallon test measure.
4. Recognize the importance of following proper safety practices and procedures when inspecting and testing retail motor-fuel dispensing systems in the field.
5. Understand the purpose and procedures for filling out report forms used by your jurisdiction.

Inspection and Test Equipment

The basic equipment required for field examinations of retail motor-fuel dispensing systems includes:

- accurate linear-measuring device, such as a tape measure,
- 5-gallon calibrated test measure, or calibrated test measure as directed by your jurisdiction,
- metal bucket,
- wide-necked metal funnel (plastic is not recommended, as explained in this chapter),
- blank inspection report forms,
- NIST Handbook 44 and copies of other procedures and codes used by your jurisdiction,
- applicable NIST Examination Procedure Outlines,
- price computation tables or hand-held calculator,
- security seals and applicator,
- inspection stickers and tags,
- fire extinguisher,
- hand tools (screwdrivers, pliers, etc.), and
- warning flags or cones.

The linear-measuring device is used to check the length of the dispenser discharge hose: maximum lengths are specified in Handbook 44.

The calibrated test measure is used to test the accuracy of the dispenser's metering device. Procedures for the care and use of this instrument are described below. Refer to Figure 4-1 for typical 5- and 10- gallon test measures.

The funnel is used to return test drafts to the storage tank after volumetric tests have been completed. A metal funnel is necessary because it will provide a ground to the storage tank fill pipe, thereby preventing a buildup of static charge, which could cause a dangerous spark. A plastic funnel will not provide a proper ground and is, therefore, not safe to use.

A metal bucket is used to catch leaks, drain vapor recovery hoods, etc.

Blank inspection report forms allow you to record the test location, applicable specifications and tolerances, inspection and test results, disposition of the device(s), and other necessary information systematically, consistently, and in a readily usable form.

A copy of the applicable NIST Examination Procedure Outline (described in Chapter 5 of this course) or procedures established by your own jurisdiction should be kept handy for reference, as should copies of relevant sections from Handbook 44 and/or other applicable codes.

Price computation tables are needed for checking the dispenser's computer, as well as any remote readouts. If metric units are indicated on the equipment you are testing, metric conversion tables found in Appendix C of NIST Handbook 44 will be required for volumetric tests. A hand-held calculator will perform these functions equally well.

Security seals are used to secure the dispenser's metering device adjustment mechanism against tampering. They are also used to prevent dispensers that have been taken out of service, as a result of testing, from being operated.

Inspection stickers are applied to dispensers to indicate the device has been inspected and found to comply with applicable requirements of NIST Handbook 44 and local jurisdiction requirements. Tags may be used to mark equipment that is required to be removed from service or for other official purposes.

A fire extinguisher is an essential item of safety equipment. Even though the station should have them, the inspector should carry his or her own extinguisher, and keep it readily available at all times.

Hand tools are required for a variety of small tasks, such as opening dispenser cabinets.

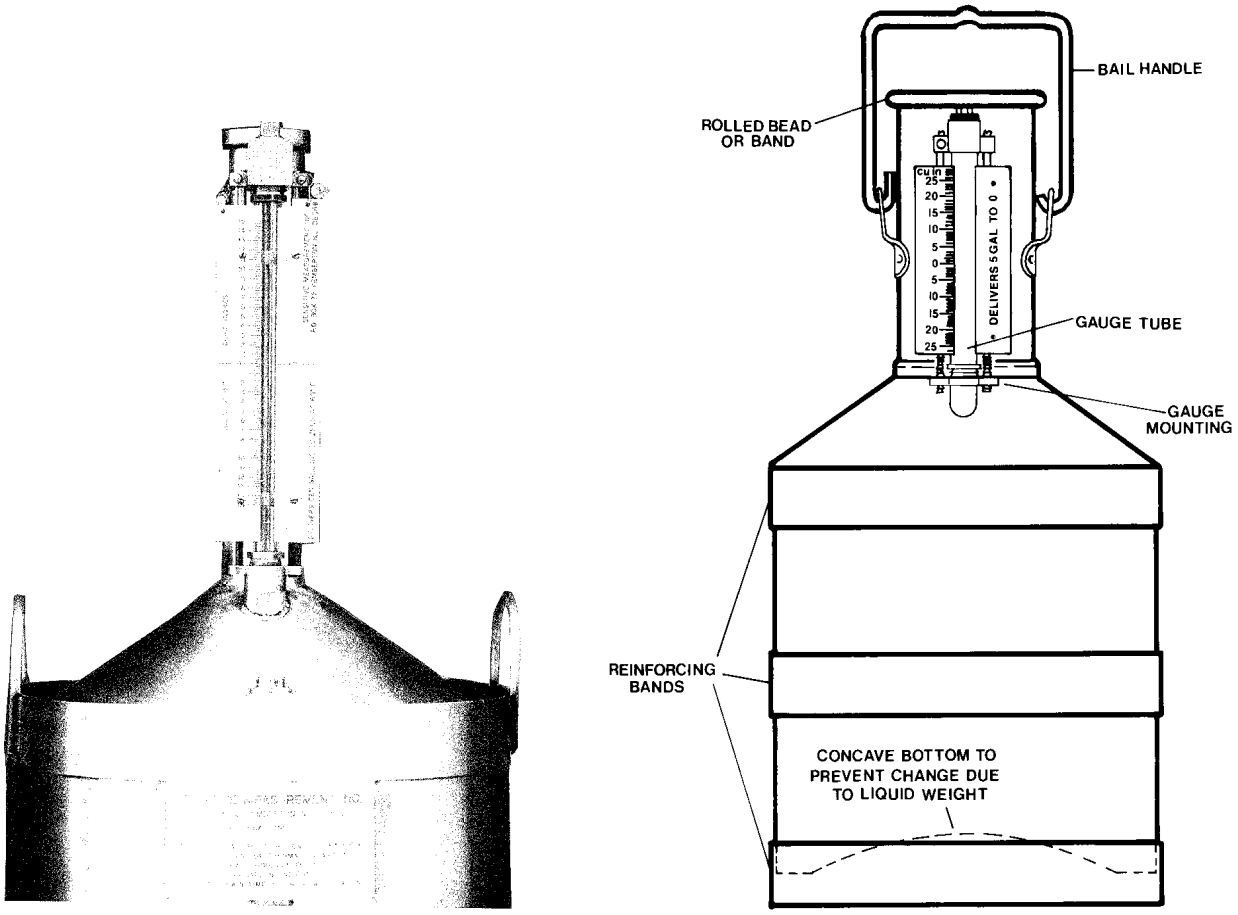
Warning flags or cones are positioned around test equipment, dispensers that are being examined, and storage tank fill openings to prevent vehicles and pedestrians from entering work areas.

This list includes all equipment required for inspecting and testing retail motor-fuel devices in accordance with Handbook 44. Other procedures established for your jurisdiction may require additional, or alternative test equipment. For example, “water paste” will be needed if your procedures call for testing storage tanks for water contamination. If “water paste” is used, be certain it is the type that can be used in gasoline and alcohol mixtures if there is any possibility that the fuel contains alcohol.

The Test Measure

Your test measure is a precision measuring device, capable of providing reliable and extremely accurate readings. It must be traceable to known standards by calibration from a Recognized Metrology Laboratory. That is, a Recognized Metrology Laboratory must verify the accuracy of the test measure before it is put into official use. In order to perform as it is designed to, it must be used and cared for properly.

Test measures come in various standard sizes, but each is designed to measure only one specific amount of liquid. The nominal capacity of the test measure should be the same as the volume of the test draft. Most test procedures for retail motor-fuel devices require drafts of 5 gallons; so a 5-gallon test measure is generally appropriate. Ten-gallon test measures are becoming more popular, especially in jurisdictions where truck mounted provers are in use. Additionally, when testing dispensers used for fueling trucks at high flow rates, a larger test measure or prover may be required (see Chapter 6). Many jurisdictions are using vehicle-mounted test units that include one or more 5-gallon test measures equipped with small holding tanks. These units enable inspectors to run multiple test drafts before emptying the holding tanks into the station's product storage tanks. Equipment availability and the policy of your jurisdiction will determine the test measure size for your use. See Figure 4-1.



Ten Gallon Test Measure Five Gallon Test Measure

FIGURE 4-1. TYPICAL TEST MEASURES

A measuring gauge is located at the top portion of the test measure. A closer view of the gauge is shown in Figure 4-2. It consists of a glass tube, which extends through an opening into the body of the test measure, and a graduated scale, which is mounted on a bracket that is adjustable for recalibration. As liquid poured into the measure approaches the specified amount, it will rise in the glass tube. The top surface of the liquid acts as an indicator, with readings taken from the graduated scale, as described below.

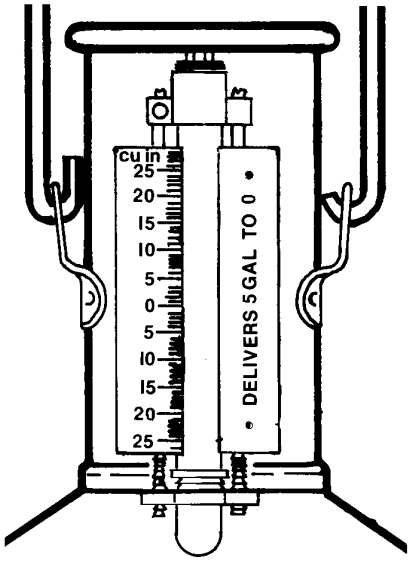


FIGURE 4-2. MEASURING GAUGE

You will notice that the gauge plate says that the measure "delivers" 5 gallons when filled to the zero line. In fact, it will contain somewhat more liquid when filled to that line. The reason for this is that no matter how much care is taken in emptying a test measure, some liquid will cling to the sides of the container. The gauge is calibrated to compensate for this clingage so that tests can be run one after another without having to take time out to thoroughly dry the measure before each test. But that means that if you begin testing with a dry measure you will need to adjust the reading for the first draft to compensate for the absence of clingage. Studies have shown that the approximate amount of clingage that will remain in a 5-gal test measure after it has been properly drained is 1 cubic inch; therefore, this amount should be deducted from the results of the first draft to allow for product clingage.

The following steps should be followed to assure accurate measurements using the test measure:

Step 1 — Inspect the inside of the measure for dirt or other foreign material and clean it if necessary. Also inspect the gauge glass, cleaning both inside and outside if necessary.

If the dispenser is equipped for vapor recovery, hold the hose as close as possible to vertical, with no upward bends, with the nozzle held vertically over a bucket, compress the vapor recovery boot, to drain any trapped liquid.

Step 2 — Dispense product into the measure until the dispenser indicator reads 5 gallons exactly.

Step 3 — Place the measure on a level surface or suspend it by the bail handle so that it hangs vertically. The test measure must be level in order to read accurately, so you may want to check the level by placing a spirit level across the top of the neck, and adjust the position of the test measure as necessary.

Step 4 — Read the measurement. The top surface of the liquid in the gauge tube will probably be slightly concave. This curvature is called the meniscus. When viewed from the side, the meniscus may appear to have some thickness, and to be lens-shaped, like the one shown in Figure 4-3. For transparent liquids, like gasoline and diesel fuel, position yourself so that the bottom of the meniscus is exactly at eye level and observe the reading on the gauge scale opposite the bottom of the meniscus.

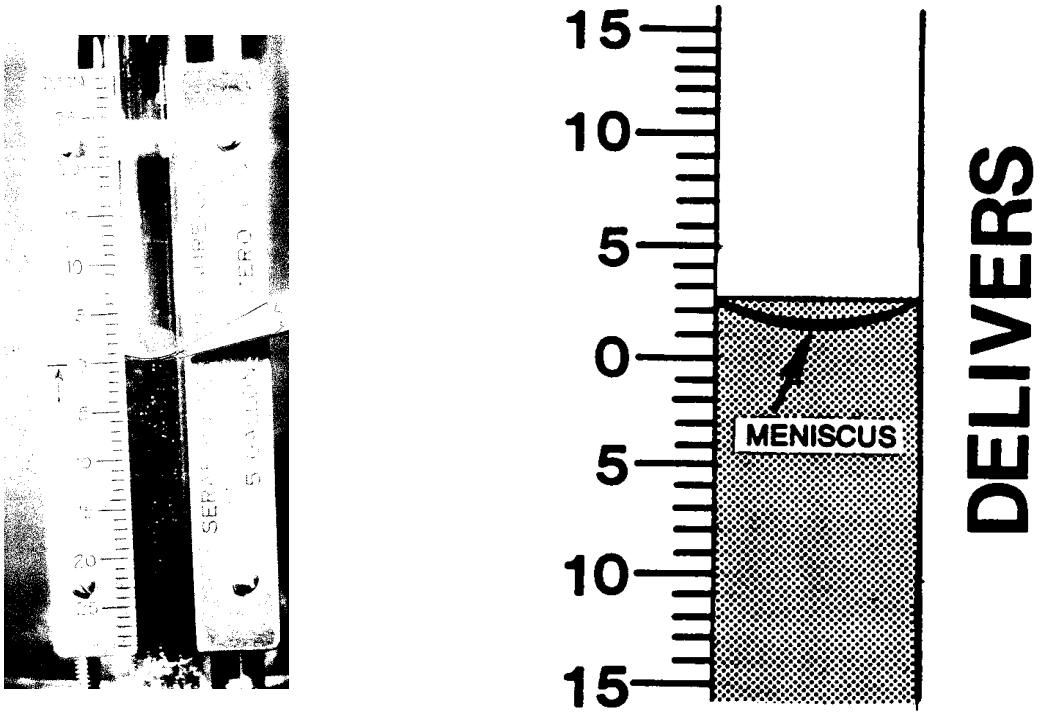


FIGURE 4-3. READING THE MEASURING GAUGE

If not exactly at the zero line, the value shown on the scale will be in "plus" cubic inches (above the zero line) or "minus" cubic inches (below the zero line). If the reading is between gauge graduations, you should always "round off" to the value of the nearest graduation. If the bottom of the meniscus is exactly in the middle of a graduated interval, read the value of the nearest even-numbered graduation. So the example shown in Figure 4-3 would be read as +2 cubic inches, because the bottom of the meniscus is midway between the +1 and +2 graduations on the gauge scale and the lower value (+1) is an odd number.

Step 5 — Record the measurement. If the test measure was dry, add 1 cubic inch to the gauge reading to compensate for the absence of clingage.

Step 6 — Empty the measure by slowly tilting and pouring product back into the correct storage tank, using a funnel. Empty slowly enough that the main flow of liquid ceases after about 30 seconds. Then, hold the measure at about 10^{o} (see Figure 4-4) from the vertical and continue to drain it for 10 seconds, and turn it upright. Do not shake the measure during this final draining.

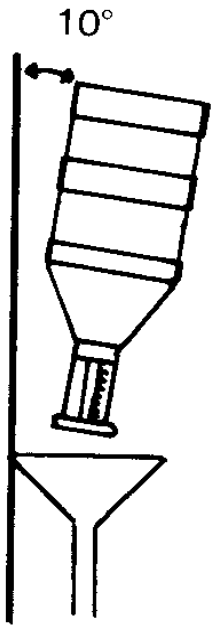


FIGURE 4-4. EMPTYING TEST MEASURE, FINAL STAGE

Repeat Steps 2 through 6 for subsequent drafts.

Care should be taken to avoid denting the test measure or jarring the gauge tube, scale, or mounting bracket. Any such damage may significantly affect the accuracy of the test measure. If damage does occur, the measure should be taken out of service immediately and repaired and recalibrated.

The inside of the measure must be kept clean and free of contaminants. It may be cleaned with detergent and water, but solvents should not be used. Since the container is made of steel, it is subject to rust, so avoid allowing water to remain inside the measure after cleaning.

Safety

Motor fuels are extremely hazardous substances and should be treated as such at all times. Wherever fuel is present in liquid or in vapor form, there is continual danger of ignition and subsequent fire and/or explosion. This is the greatest safety hazard you will encounter when testing and inspecting fuel-dispensing systems, but it is by no means the only one. As an inspector, you have the responsibility for not only your own safety, but also the safety of station employees, customers, and others in your work area.

Your jurisdiction will have established safety guidelines and procedures. These should be studied carefully and followed to the letter, both in the field and during training exercises. The following is a list of some general safety precautions.

- Do not smoke or permit smoking, flame, or sparks in the vicinity of dispensers or storage tank fill openings or vent pipe.

- Open both sides of dispenser cabinets and permit any fumes trapped inside to dissipate before proceeding with the inspection of the interior of the device.

- Look carefully for leaks and report any found immediately to station supervisory personnel. Your jurisdiction's policies may specify that you not proceed with inspection until the source of the leak is discovered and corrected or that, if necessary, the device must be taken out of service until the leak is repaired. Your instructor will explain these policies to you.

- Eliminate sources of possible static electricity. Do not wear nylon jackets or other fabrics that are likely to produce static. Be sure to use a metal funnel for returning product to storage tanks, and ground the test measure against the metal funnel. Make sure the nozzle is grounded against the test measure when taking a test draft.

  Do not use a test measure that has been used for drafts of gasoline to measure diesel fuel until you are certain that all gasoline vapors have dissipated. This practice, called "switch-loading," is extremely hazardous because diesel fuel is likely to produce a static charge while being dispensed. Sparks from this charge could easily ignite gasoline vapors inside the measure.

  There have been incidents where consumers have experienced flash fires when filling gasoline cans in the bed of a pick-up truck with a plastic bed liner. As a further precaution never place the test measure in the bed of a pick-up truck with a plastic liner when drawing your test draft. Always be certain the test measure is grounded and is in contact with the nozzle when taking a test draft.

- Determining which wiring within the hydraulic cabinet of the dispenser that must be enclosed (in a conduit) is not as clear cut as it was several years ago. Many newer dispensers contain "intrinsically safe" wiring within the hydraulic cabinet that is not required to be enclosed. Safety laboratories have

determined that these circuits do not carry enough current to generate a spark, and the wiring is therefore not required to be encased in a conduit. Wiring to the pulser, the pump handle switches, and some selector push buttons in an electronic dispenser, for instance, usually fall within this category.

Generally wiring inside the hydraulic area of the device, which powers higher current components, must be enclosed in a conduit. These would be components like motors, solenoid valves, lighting systems, speakers and the like. The cover of the explosion proof junction box must be in place and securely fastened. Look for any exposed power wiring that originates from the explosion proof junction box and, if found, report it to the station supervisor immediately. Do not proceed with inspection until the condition has been corrected. If necessary, depending on your jurisdiction's policies, you may require that the pump be taken out of service until repaired.

- Do not leave devices activated and unattended. While the system is pressurized, the possibility exists for leakage, which must be observed immediately.

- Always use your metal funnel when returning test drafts to storage tanks to prevent spillage. Ground the test measure against the funnel when pouring the product.

- Avoid inhaling motor-fuel fumes or vapor. Prolonged or frequent inhalation of these substances may be hazardous to your health.

- Wear rubber-soled, treaded shoes to reduce the risk of sparks and provide secure footing on pavement that may be slippery as a result of fuel or lubricant spills.

- Watch out for vehicles moving in or out of the station area. Drivers are generally less attentive when traveling at slow speeds, and are often distracted while looking for a particular product dispenser or vacant pump.

This list of general precautions is not intended to replace specific safety procedures established by your jurisdiction. As part of the requirements for successful completion of this course, you should obtain copies of official safety guidelines and procedures, study and review them with your instructor, and practice them thoroughly.

Report Forms

Every official action you take as an inspector must be recorded, and reports of that activity are used in different ways. For the examination of retail motor-fuel dispensers, you will need to keep records of:

- the dispensers examined,

- the findings in that examination,

- the decision on acceptability of the dispenser, and

- action taken as a result of that decision.

The Uniform Weights and Measures Law in NIST Handbook 130, which has been adopted by most States, requires that adequate records be maintained; but only infrequently, if at all, do these statutes describe the details of the records.

A good report form should:

- Be complete enough, legible, and in a suitable form so that it is the primary record; that is, it should not be necessary for someone to copy the report information onto other records.

- Provide a detailed record of the work performed by the inspector. In the case of examination of retail motor-fuel dispensers, it should contain space for all the information you will gather when you follow the Examination Procedure Outline.

- Give the owner or operator of the device a clear understanding of the compliance or noncompliance of his or her equipment and the official action taken as a result of the test.

- Serve as a guide to the serviceperson in the repair of a rejected device.

- Provide an historical record of individual devices and establishments, with necessary data from which statistics may be derived.

- Be a simple design, easy to use, and easy to understand.

At this time, every jurisdiction has different report forms and systems unique to that jurisdiction. Your instructor will explain the use of the report forms used in your jurisdiction.

For comparison, Figures 4-5 and 4-6 on the following pages are representative sample report forms. These have been selected from the many different types of forms in use at this time.

SUMMARY

The weights and measures official takes a variety of tools into the field. Among these are the tools and instruments that are used to test the device, the report forms that facilitate test procedures and administrative procedures and are used to document the results of the inspection and test, and the knowledge that is required to make practical and effective judgments under various conditions. The inspector must know how to use and maintain all of these tools. A thorough and confident knowledge of safety practices and the conditions that may necessitate their application is also essential, since retail motor-fuel dispensers are used to measure and dispense hazardous substances.

Bob Crawford
Commissioner

1 - SEND TO DIVISION OF STANDARDS

DATE OF INSPECTION MO. DAY YEAR

STATE OF FLORIDA
DEPARTMENT OF AGRICULTURE AND CONSUMER SERVICES
PUMP INSPECTION REPORT

FILE NO. 03014
PUMP INSPECTION REPORT NUMBER

STATION OR FACILITY NO. _____ INSP. CODE _____ COUNTY _____ LOCATION ADDRESS _____ LOCATION CITY AND STATE _____

LOCATION ZIP CODE _____ MAILING ADDRESS _____ MAILING CITY AND STATE _____ MAILING ZIP CODE _____

STATION OR STORE NAME _____ OWNER OR MANAGER _____

STATUS [ ] 1 = ACTIVE 2 = TEMP. CLOSED 3 = OUT OF BUSINESS

GASOLINE PUMPS ACTIVE [ ] INACT. [ ] OTHER PUMPS ACTIVE [ ] OTHER PUMPS INACT. [ ] ACTIVE STORAGE TANKS GAS [ ] KERO [ ] DIESEL [ ]

NAME AND SERIAL NUMBER OF PUMPS AT THIS LOCATION	PUMP STATUS 1 = INACT 2 = REMOVED 3 = O.O.P. 4 = LIMITED	PRODUCT 1 = GAS 2 = KERO 3 = DIESEL 4 = PMIX 5 = OTHER	CLASSIFICATION 1 = AUTO 2 = STROKE	TESTING DRAFT 1 = 1 GAL. 5 = 5 GAL. M = METRIC	ERROR FAST (+ OR -)	ERROR SLOW (+ OR -)	TOLERANCE USED 1 = ACC 2 = MAINT	TOLERANCE 1 = OK 2 = OUT	SAMPLE TAKEN 1 = YES 2 = NO	ATTRIBUTES INCORRECT (ENTER CODE)	REPAIR TIME LIMIT 00-CONDEMNED OR ENTER NO. OF DAYS	GALLONS OR LITRES RETURNED TO TANK	MECHANIC SEAL	REMARKS

ATTRIBUTE CODES: 1 = NOZZLE CHECK VALVE 2 = INDICATOR 3 = IMPROPERLY LABELED 4 = INTERLOCK 5 = COMPUTER 6 = AIR ELIMINATOR 7 = GLASS 8 = METER NOT SEALED 9 = LEAK 0 = OTHER

THE FOLLOWING PUMPS WERE FOUND NOT TO COMPLY WITH THE GASOLINE INSPECTION LAW:

PUMP NAME AND NUMBER	FOUND SHORT	FOUND OVER	OTHERWISE INCORRECT

ENTER CONDEMNED OR TIME ALLOWED _____ DAYS FOR CORRECTION

X _____ PERSON IN CHARGE AT TIME OF INSPECTION

_____ INSPECTOR _____ NUMBER _____ PHONE NUMBER

Bob Crawford
BOB CRAWFORD
Commissioner of Agriculture

PUMPS WERE CORRECTED ON MO. [ ] DAY [ ] YEAR [ ]

BY AUTHORIZED MECHANIC OR OTHER RESPONSIBLE PARTY — PHONE NUMBER — MECHANIC CERTIFICATE NO. (REQUIRED)

X _____

AS SOON AS CORRECTIONS ARE MADE SIGN THIS NOTICE AND RETURN TO: **DIVISION OF STANDARDS, 3125 CONNER BLVD., TALLAHASSEE, FLORIDA 32399-1650**

FIGURE 4-5. SAMPLE REPORT FORM

Maryland Department Of Agriculture
Weights and Measures Section
50 Harry S. Truman Parkway
Annapolis, Maryland 21401
Telephone (410) 841-5790

PAGE ______ OF ______

DATE OF INSPECTION

NO. OF METERS

SMALL LIQUID MEASURING DEVICE REPORT

REPORT NO.

FIRM | ACCOUNT NO. | PHONE NO.

ADDRESS | COUNTY | TIME IN/TIME OUT

CITY | ZIP | OWNER/MGR. | DATE LAST INSPECTED

I acknowledge receipt of this report and certify that I understand the violations or instructions described herein. | RECEIPT ACKNOWLEDGED | INSPECTOR

Device No.	Make/Model	Serial No.	Violation Key	Test	Prover Reading	Action Taken			Totalizer		Total Gal./L	Product
						App.	Rej.	Cond.	After Test	Before Test		
				N								
				S								
				N								
				S								
				N								
				S								
				N								
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***VIOLATION KEY**

A Other ______________________
B Unit price not properly displayed.
C Quantity/Total Price inappropriately displayed.
D Security seal not affixed to meter adjustment.
E G-UR.4.1. Maintenance of Equipment.
F Computer advances prior to delivery.
G Other ______________________
H Other ______________________
I Automatic Nozzle Malfunctioning.
J Anti-drain valve malfunctioning.
K Leaks downstream of meter.
L Digital segments malfunctioning.
M Meter inaccurate.
N Other ______________________

DISTRIBUTION

Original	Office
Canary	Inspector
Pink	Proprietor
Goldenrod	Proprietor

☐ All violations must be corrected by __________ . Device(s) still in violation after this date may be condemned out of service.

REMARKS: ____

MDA-B203-Rev (2/95)

FIGURE 4-6. SAMPLE REPORT FORM

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REVIEW QUESTIONS AND ANSWERS

Circle the correct answer(s) for each question or respond as otherwise indicated. If a multiple choice question does not specifically ask for "all correct answers," it may be assumed that only one of the answers listed is correct.

1. Describe briefly what the following items of test equipment are used for:

   a. linear-measuring device _____

   _____

   b. price computation tables _____

   _____

   c. security seals _____

   _____

2. A metal funnel is used:

   a. to fill the test measure.

   b. to return product to storage tanks after testing.

   c. to remove water from storage tanks.

   d. (a) and (b) only.

   e. all of the above.

3. True or False: A 10-gallon test measure can be used to test 5-gallon drafts.

4. Test measures are calibrated to be used "wet" in order:

   a. to compensate for evaporation of test liquid during dispensing and measurement.

   b. to lubricate the inside of the container so that air bubbles will not form and cling to the sides.

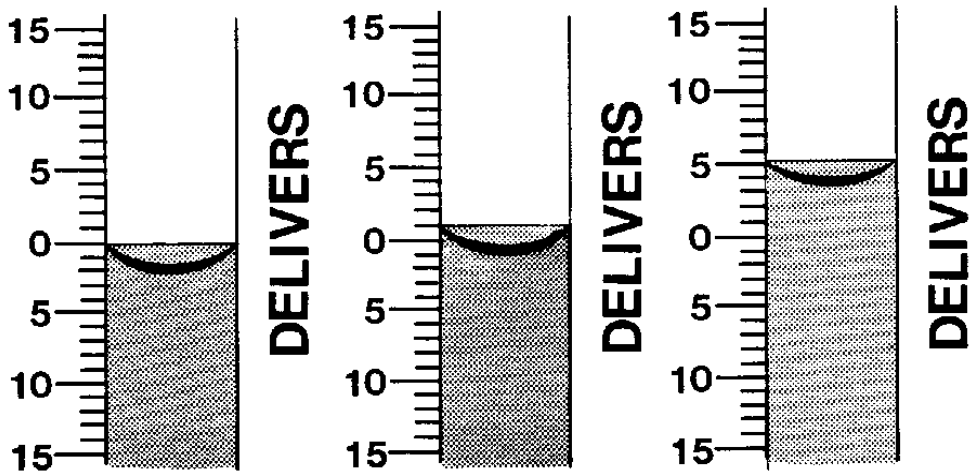
   c. to compensate for test liquid remaining in the measure after a previous draft has been emptied.

   d. to assure that contaminants have been flushed from the inside of the container before use.

   e. all of the above.

5. When emptying a test measure, the measure should be held at an angle of 10° from the vertical for 10 seconds until/after the main flow has ceased. (Cross out incorrect answer.)

6. Record values for the following test gauge readings:



a. _____ b. _____ c. _____

7. Where are specific safety guidelines and procedures for your jurisdiction located? Give title and/or description of document and tell where copies can be obtained.

CHAPTER 5

THE INSPECTION

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Use the Examination Procedure Outlines (EPOs) developed by NIST for retail motor-fuel dispensers.

2. Describe the purpose of the inspection portion of the EPO and each of its major elements.

3. Describe the procedures employed in routine inspections.

INTRODUCTION

What you have learned about the prominent role of retail motor-fuel dispensers in the commercial marketplace should help you appreciate the importance of your jurisdiction's program of regular field examinations for dispensers currently in service. Similarly, the basic knowledge you have acquired about the design and operation of these sophisticated liquid-measuring devices should make it obvious that systematic procedures must be employed for inspecting and testing them. Given the complexity of the retail motor-fuel dispensing system and the number of individual components that must function correctly to provide accurate and consistent measurement, a haphazard approach would at best be inefficient, requiring excessive time and effort to achieve complete and significant results, and thereby diminishing the overall effectiveness of the program. At worst, a haphazard approach could lead to overlooking or misinterpreting significant data, thereby compromising—even invalidating the entire examination. In this chapter and those that follow you will receive a thorough introduction to examination procedures that employ a systematic approach to inspection and testing.

The purpose of an official weights and measures examination is to determine whether the device being examined meets requirements that are established by law or by legally mandated regulation. Thus, legal requirements form the basis of all examination procedures, and a thorough knowledge of applicable codes and administrative policies is as important a part of the inspector's job as knowing how to use a test measure or how to conduct a slow-flow test.

Most jurisdictions have adopted the comprehensive specifications, tolerances, and other technical requirements set forth in NIST Handbook 44. The requirements that apply to retail motor-fuel dispensers are included in Sections 1.10 (General Code) and 3.30 (LMD Code) of the handbook. These codes will be referenced throughout the following discussions. Some jurisdictions have modified portions of these codes, and in some jurisdictions, additional requirements have been imposed by State or local laws and regulations. Your instructor will point out specific differences between Handbook 44 and the applicable codes in force in your jurisdiction and explain the significance of these differences.

Codes provide the basis for field procedures, but they are organized in a way that suits their primary function as legal documents and as a result are often not very well suited to use in the field. Specific requirements that

govern a particular component or feature of the fuel-dispensing system—like the zero-setback mechanism—sometimes occur at separate places in the codes, and some requirements are applicable to more than one element of the system. In recognition of the need for a more systematic organization of requirements, one that is suited to efficient field procedures, the Office of Weights and Measures at the National Institute of Standards and Technology has developed Examination Procedure Outlines (EPOs) for many weighing and measuring devices, including retail motor-fuel dispensers.

Figure 5-1, on the next page, is the first operations page of EPO 21 for single-, dual-, and multi-product dispensers. Differences in design and operating characteristics necessitated the development of separate EPOs for single, dual, and multi-product systems (EPO 21) and blended-product systems (EPO 22). As you can see, the EPO provides a systematic organization, referencing the applicable paragraphs of the Handbook 44 codes for each of the major functional components of the system that are involved in measuring and indicating deliveries. As you will see in the next chapter, a subsequent portion of the EPO presents a step-by-step procedure for conducting a series of performance tests. Because of its systematic organization, the EPO is a useful guide for the inspector in the field, and is also a tool that can be used by the inspector as a checklist, to ensure that all the steps in the examination have been performed. Pages one and two of the EPO contain important safety-related information with which each inspector must be familiar. The information on these two pages is important to your safety and well being.

The EPO is intended as an outline of what should be considered a minimum examination procedure. When the inspector encounters a device that has features that are "new" to him or her or in non-routine examinations (conducted in response to complaints, or when there is reason to suspect that the device is being used improperly or to facilitate fraud), further procedures are likely to be needed.

Complete copies of EPO 21 (single, dual, and multi-product retail motor fuel dispensers) and EPO 22 (blended-product retail motor-fuel dispensers) are included in the Appendix to this manual. These EPOs should be updated periodically to include changes in the codes or policies of your jurisdiction.

An official field examination consists of four components:

- The Inspection, to determine compliance with specifications and other requirements;
- Pretest determinations, to assure the correct application of tolerances and other test factors;
- The Test, to determine compliance with performance requirements; and
- The Evaluation of Inspection and Test results, followed by approval or rejection of the device.

This division is based upon distinctions which are observed in Handbook 44 and in the EPOs. Notice that the terms, "inspection," "test," "evaluation," and "examination," refer to specific and different activities ("examination" comprising the other three terms). These distinctions will become clear as we discuss the separate components in concrete terms.

EPO No. 21 (Excerpt)

Examination Procedure Outline for

Retail Motor-Fuel Dispensers
Single, Dual and Multi-Product
(Except Blenders)

	H-44 General Code and Liquid-Measuring Devices Code References
1. General considerations	
Selection	G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3.
Installation	G-S.2.,G-UR.2.1.,G-UR.2.2., UR.2.1., UR.2.4.
Position of equipment	G-UR.3.3.
Accessibility	G-UR.2.3.
Assistance	G-UR.4.4.
Use and maintenance	G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.3.5.
2. Indicating and recording elements	
Design	S.1.1.
Units	S.1.2.1., S.1.2.3.(a)
Readability	G-S.5., G-S.6.(1/1/77), G-S.7., S.1.4., S.1.5.
Values of intervals	G-S.5.3., G-S.5.3.1.
Indication of delivery	S.1.6.1.,
Money-value divisions	
Analog	S.1.6.5.1.
Digital	S.1.6.5.2.
Auxiliary indications	S.1.6.5.3. (1/1/85)
Unit Price and product identity	S.1.6.4.1.(a), S.1.6.4.2., UR.3.2.
Multiple unit price dispensers	S.1.6.4.1.(b) (1/1/91), S.1.6.5.(a) (1/1/91), S.1.6.5.4. (1/1/91), UR.3.3.
Advancement and return to zero	S.1.3., S.1.6.3., UR.3.1.
Recorded representations, point of sale systems	S.1.6.7. (1/1/86)
Provision for sealing	G-S.8. (1/1/90), G-UR.4.5., S.2.2.(a&b), S.2.2.(c) (1/1/95), Table S.2.2. (1/1/95)
3. Marking	G-S.1.,G-UR.2.1.1.,G-UR.3.4., S.4.1., S.4.4.1. (1/1/85), S.4.4.2. (1/1/03)

FIGURE 5-1. EPO FOR RETAIL MOTOR-FUEL DISPENSER, INSPECTION

INSPECTION

The first part of the EPO is devoted to Inspection (see Figure 5-1). In the Inspection portion of the official examination, you will determine the dispensing system's compliance with specifications and other requirements pertaining to design, installation, and operation. The extent and emphasis of your inspection will depend on a number of factors relating to the specific device being tested and the circumstances under which it is being tested. Some of the more important factors are:

- your familiarity with the device,
- the age of the device,
- whether or not the device is of a type that has been type evaluated, and
- whether or not a complaint has been received.

Naturally, your previous experience with the particular device and then location (business) will impact on the inspection process. If this is a first time inspection of the device or location (business), you may want to perform an extensive inspection that includes a careful check of all applicable requirements in Handbook 44, including those concerned with design and installation. If you are checking a device you are familiar with, one that has been in service for some time, you may not need to spend much time on design and installation requirements; however, you will want to look for such things as fraudulent use or abuse of the equipment and inappropriate applications of the device.

The age of the device—when it was manufactured and when it was put into commercial service—is important because a number of requirements in Handbook 44 are nonretroactive as of a certain date. As a result, you will find that old equipment will be required to meet a different set of requirements than new equipment.

In most cases, the device you will be testing will be of a type that has been evaluated under the National Type Evaluation Program (NTEP). NTEP, which is managed by the National Conference on Weights and Measures (NCWM), Inc., is a program for determining conformance of a weighing and measuring device "type" or "model" with the relevant provisions of Handbook 44. Manufacturers voluntarily submit models of their devices for evaluation under the NTEP program. An authorized State or Federal government laboratory conducts the evaluation. When a device is found to meet all applicable technical requirements, the NCWM issues a Certificate of Conformance (CC) for that device. The CC provides details of the evaluation results and device characteristics necessary for inspection and use in commerce.

Before testing a new type of device, you should determine if a model of the device has been type evaluated. If it has, you should review the CC issued to the device to determine which features have been evaluated. Copies of the CCs are available from the manufacturer and from State weights and measures jurisdictions. Copies of CCs are also available are available at NTEP's web site on the Internet at *http://www.ncwm.net*.

During the type evaluation process, extensive tests are performed to determine if a particular device model meets all applicable requirements in Handbook 44. Some of these tests are difficult (if not impossible) to perform correctly in the field; consequently, the existence of a Certificate of Conformance can make your job easier—during a field inspection, you may not need to extensively examine certain design criteria on a type evaluated device. But remember that type evaluation means that a model of a device has been examined, not each device; therefore, you should still review all applicable requirements when inspecting a new device. The review may simply consist of a brief visual check of an item.

Devices are designed with specific applications in mind. Some devices are designed for a narrow range of applications, whereas others have a multitude of features to satisfy many different applications. Not all features are suitable for all applications. A CC will state the application of a device type that is covered on the CC. Use of the device in applications other than those listed on the CC are not covered by the CC. If you encounter a new or unusual device or feature on a device in an unusual application, it should be thoroughly tested to determine its appropriateness and to assure that is does not facilitate fraud.

Another factor that affects the nature and extent of the Inspection portion of your examination is the existence of a complaint about a particular device or the practices of a device owner or operator. You may want to perform a more extensive inspection than usual if your office has received complaints about a device or business.

As you will see in the detailed discussion that follows, most Inspection determinations are made on the basis of a careful visual examination and the inspector's experience and knowledge of the device. This does not mean, however, that the Inspection may be approached casually, or that compliance with any requirement can be taken for granted just because the device has received approval. It is not at all uncommon to discover noncompliance in a number of areas covered in the Inspection, especially when the equipment is old or has not been properly maintained. Furthermore, it is much more likely that modifications intended to facilitate fraud will show up in the course of a careful inspection than in performance tests.

You should also keep in mind that your inspection is not limited to visual means, or any other. It is the inspector's responsibility to decide what is necessary to determine the compliance status of the device. If you have reason to believe that a correct determination requires additional testing, either in the field or under more controlled conditions, you should consult your supervisor so that appropriate arrangements can be made. However, the cost of additional testing to the owner or operator of the equipment, including the cost of lost productivity while it is out of service, must not constitute an unreasonable burden. The decision to conduct additional testing will generally involve weighing the probability that a suspected violation will be confirmed against the cost of testing—including the cost to the jurisdiction. So you should be prepared to explain and justify your recommendation.

The remaining sections of this chapter will present the inspection procedures for retail motor-fuel dispensers. Each of the items included in the EPOs will be discussed in detail. However, in the interest of providing a basic framework for field procedures, we will begin with the General Considerations and Marking sections of the EPO, but some of the sub-headings will be presented in modified order. The inspection portion of the EPO (21) for Single, Dual, and Multi-product) retail motor-fuel dispensers and the EPO (22) for blended-product dispensers are identical; specific differences will be pointed out as we proceed.

General Considerations

The items under this heading refer, for the most part, to requirements and specifications from the General Code that are necessarily broad and comprehensive in nature. They may relate specifically to items covered in earlier sections of the Inspection or to the Test portion of the examination. They are nonetheless important, and should not be ignored simply because they are general in nature. On the contrary, the inspector should keep in mind and refer to these General Considerations throughout the examination procedure.

Accessibility

Because fuel dispensers are designed and intended to be positioned and readily accessible to the public, accessibility for the weights and measures official is rarely a problem (an example of an exception to this is boat marinas, where the dispensers may be located in remote areas that can be reached only by boat). The inspector must have access not only to the dispensers (including the inside of dispenser cabinets), but also to storage tank fill pipes and any remote primary indicating or recording elements, such as a control console located in a cashier's office.

G-UR.2.3. Accessibility for Inspection, Testing, and Sealing Purposes. - A device shall be located, or such facilities for normal access thereto shall be provided, to permit:

(a) inspecting and testing the device;

(b) inspecting and applying security seals to the device; and

(c) readily bringing the testing equipment of the weights and measures official to the device by customary means and in the amount and size deemed necessary by such official for the proper conduct of the test.

Otherwise, it shall be the responsibility of the device owner or operator to supply such special facilities, including such labor as may be needed to inspect, test, and seal the device, and to transport the testing equipment to and from the device, as required by the weights and measures official. (Amended 1991)

There is no specific inspection procedure for this item. It is the responsibility of the proprietor to provide and facilitate access, including transportation for the inspector and his or her equipment to a remote or controlled-access location (as sometimes required at marinas and airports). In the case of aboveground storage tanks, a safe means of access must be provided to the top of the tank if the inspector must return product there.

Keys to locked cabinets, fill access covers, and other secure areas to which the inspector must have access during the field examination must be provided (see Assistance, below).

Assistance

Assistance is generally not required for the examination of retail motor-fuel dispensers. However, the proprietor or operator may be needed to gain access to locked dispenser cabinets, storage tank filler pipes, etc., as well as to activate key-, card-, or coin-operated dispensers.

G-UR.4.4. Assistance in Testing Operations. - If the design, construction, or location of any device is such as to require a testing procedure involving special equipment or accessories or an abnormal amount of labor, such equipment, accessories, and labor shall be supplied by the owner or operator of the device as required by the weights and measures official.

In addition, at facilities with aboveground storage tanks, assistance may be required either in returning product to the top of the storage tanks or in operating a pump return.

Selection

To be suitable for its application, a motor-fuel device should be capable of indicating volume and computing prices for all deliveries for which it is normally used. In addition, it must have such other features as are available and appropriate to its usual service.

For example, for dispensers installed in service stations that serve primarily cars and small trucks, the largest single delivery is likely to be no more than 30 gallons. However, dispensers installed at truck stops or other stations that often serve large trucks may make single deliveries of 100 gallons or more. Such devices may need to be specially equipped with computers capable of computing and displaying total sales prices for these larger deliveries. A device that is often used for deliveries to large trucks that is not so equipped might not be suitable for its application. Devices must also be capable of producing accurate measurement over a range of flow rates (usually from 5 to 15 gpm for pumps used primarily to service automobiles; those used primarily for sales to trucks have maximum discharge rates of 20 gpm and more).

The increased use of self-service marketing concepts, including self-pay and self-operated systems has understandably led to some confusion on the part of motorists, who must deal with equipment whose operation is different from what they are accustomed to and often, from their point of view, quite complex. It is of primary importance that consumers be able to understand the transactions they are undertaking and that indicators and operating elements designed to be used by them be clear. There should be no question as to what product the consumer is purchasing and how much the purchase will cost. Specific requirements relating to the design, marking, and use of devices used in multi-tier pricing applications will be discussed below.

G-UR.1.1. Suitability of Equipment. - Commercial equipment shall be suitable for the service in which it is used with respect to elements of its design, including but not limited to its weighing capacity (for weighing devices), its computing capability (for computing devices), its rate of flow (for liquid-measuring devices), the character, number, size, and location of its indicating or recording elements, and the value of its smallest unit and unit prices.

Ultimately, the selection and installation of suitable equipment serves the interest of the owner as well as the motorist, since increased efficiency and customer satisfaction will contribute to the commercial success and profitability of the operation.

There is no specific inspection procedure for this general requirement, although its scope and potential application are broad, especially in circumstances where more specific requirements in the LMD Code do not apply. The inspector should bear in mind the suitability of the equipment in operation for the type of service provided. At the same time, it is not the responsibility, or the role of the weights and measures official to dictate the proprietor's method of marketing or delivering his service. Rather, you should assure yourself that equipment in use is not unsuitable for its application.

Installation

Proper installation involves considerations of security, safety, and mechanical operation. The EPOs reference several paragraphs from Handbook 44 that relate to installation.

G-UR.2.1. Installation. -A device shall be installed in accordance with the manufacturer's instructions, including any instructions marked on the device. A device installed in a fixed location shall be so installed that neither its operation nor its performance will be adversely affected by any characteristic of the foundation, supports, or any other detail of the installation.

G-UR.2.1.1. Visibility of Identification. - Equipment shall be installed in such a manner that all required markings are readily observable. (Added 1978)

G-UR.2.2. Installation of Indicating or Recording Element. - A device shall be so installed that there is no obstruction between a primary indicating or recording element and the weighing or measuring element; otherwise there shall be convenient and permanently installed means for direct communication, oral or visual, between an individual located at a primary indicating or recording element and an individual located at the weighing or measuring element. [See also G-UR.3.3.]

UR.2.1. Manufacturer's Instructions. - A device shall be installed in accordance with the manufacturer's instructions, and the installation shall be sufficiently secure and rigid to maintain this condition. (Added 1987)

UR.2.4. Diversion of Liquid Flow. - A motor-fuel device equipped with two delivery outlets used exclusively in the fueling of trucks shall be so installed that any diversion of flow to other than the receiving vehicle cannot be readily accomplished and is readily apparent. Allowable deterrents include, but are not limited to, physical barriers to adjacent driveways, visible valves, or lighting systems that indicate which outlets are in operation, and explanatory signs. (Amended 1991)

- Installation must follow manufacturer's specifications. Most manufacturers furnish detailed instructions for installation of a new dispenser. These instructions, and any associated specifications, are designed to assure that the system will perform efficiently and accurately. Installation that does not follow these specifications, or non-approved modifications to the equipment made after its installation, are violations of G-UR.2.1.

- The device must not be installed in such a way that required markings are obscured or obstructed. For the markings required for retail motor-fuel devices, see **Marking Requirements**, below.

- Primary indicating elements must be visible from the position at which the operator of the pump stands. In the case of retail motor-fuel devices, indicators must be provided on both sides of the dispenser (unless operation is not possible from one side. (See also G-UR.3.3., under **Position**, below, for a related requirement, and see S.1.6.4. and S.1.6.5., discussed under **Indicating and Recording Elements**, below, for an extension of this requirement to the display of unit price and product identity.)

- Multiple-outlet dispensers must be installed in such a way that they do not facilitate fraud. This requirement applies only to dispensers that are specially equipped with two discharge outlets that can be used simultaneously for a single large delivery of product to a truck. If an unscrupulous operator were to divert product through one of these hoses to some receptacle other than the truck's receiving tank while normal delivery was being made through the other hose, the customer could be charged for product he or she had not received. It is practically impossible to design a dispenser that makes such fraudulent use impossible. However, a dispenser with such special equipment must not be installed in a manner that would make it easy or convenient for an unscrupulous operator to abuse the device in this way (for example, by positioning the dispenser where some physical obstruction makes it difficult or impossible for the customer to see the entire length of both discharge hoses). Specific

design requirements for multiple-outlet devices are established in paragraphs S.3.1 and S.3.2., which are discussed later in this chapter.

It is obviously impracticable to check every item included in the manufacturer's installation instructions as part of a routine examination. However, you should at least check to determine:

- that the dispenser chassis is securely bolted to the service island;
- than an impact valve is installed on a remote dispenser, that its breakaway mechanism is clear of debris, and that the valve is not wired or blocked open; and
- that there is no exposed wiring, and that all wiring is enclosed in conduit or junction boxes.

If, in the course of subsequent inspection or test procedures, you have reason to believe that substandard condition or performance of the equipment results from incorrect installation, you may wish to consult the manufacturer's specifications for particular items.

In addition, you should determine any special requirements marked on the device for accessory, auxiliary, or remote components and inspect these.

Position

Both buyer and seller participate in a direct sale. When weighing and measuring or computing devices are used in such transactions, it is essential that the information they provide be available to the customer as well as the seller. This provides some protection for the customer from accidental or intentional errors made by the seller. It is for this reason that weighing and measuring devices in retail stores must be positioned so that they can be read simultaneously by the customer and the salesperson.

G-UR.3.3. Position of Equipment. - A device equipped with a primary indicating element and used in direct sales, except a prescription scale, shall be so positioned that its indications may be accurately read and the weighing or measuring operation may be observed from some reasonable "customer" position. The permissible distance between the equipment and a reasonable customer position shall be determined in each case upon the basis of the individual circumstances, particularly the size and character of the indicating element. (Amended 1974)

For retail motor-fuel devices, primary indicating elements must be readable when viewed from a "reasonable customer position." What is a reasonable customer position will obviously depend to some degree on the type of service offered at the pump: that is, whether the customer is likely to be observing the indicator during delivery from behind the wheel of his or her vehicle or, in the case of a self-service station, from some position outside the vehicle.

Inspect devices from the customer's point of view to determine whether primary indicating elements are not only visible but readable:

- at the time when the dispenser is reset to zero;
- throughout the course of delivery; and
- at the time when the dispenser on/off switch is put in the off position, terminating the delivery.

Use and Maintenance

The accurate performance of any measuring device depends upon proper use and maintenance. The General Code therefore includes broad requirements for these activities (G-UR.3.1. and G-UR.4.1.).

> **G-UR.3.1. Method of Operation.** - Equipment shall be operated only in the manner that is obviously indicated by its construction or that is indicated by instructions on the equipment.
>
> **G-UR.4.1. Maintenance of Equipment.** - All equipment in service and all mechanisms and device s attached thereto or used in connection therewith shall be continuously maintained in proper operating condition throughout the period of such service. Equipment in service at a single place of business found to be in error predominantly in a direction favorable to the device user shall not be considered "maintained in a proper operating condition." (Amended 1973, 1991)

All motor-fuel devices are equipped with an on/off switch and a discharge lever on the nozzle. The design of both of these elements (which is, in part, specified by Handbook 44, as you will see below) makes their misuse virtually impossible. The operation of these controls is obvious; however, instructions are usually provided, especially at self-service stations. Instructions are also often provided for dispensers with vapor recovery nozzles; again, these are useful but not required. In the case of devices equipped with additional controls, such as service, payment, or product selectors, or self-pay, card-, or key-operated devices, instructions for correct use should be displayed on the dispenser or on the dispenser display. It is the responsibility of the device owner or operator to operate the equipment consistent with any markings on the device and to use the device in such a manner as indicated by the construction of the device.

For fuel dispensers, the responsibility of the owner or operator to maintain equipment in proper operating condition includes (but is not limited to):

- readability of indicating elements;
- accuracy of the measuring device;
- repair or replacement of defective nozzles and discharge hoses.
- repair of leaks; and
- replacement of broken glass.

When examination reveals that most equipment in service at a single location errs in favor of the owner, the equipment is considered not to be "maintained in a proper operating condition," even if errors for individual devices do not exceed applicable tolerances. This is to prevent a proprietor from benefiting from the cumulative error of a number of devices. For example, if five of six pumps are found to over register, all of these pumps can be considered to be out of compliance, even if individual errors do not exceed compliance limitations.

A determination regarding the general maintenance of all devices at the same location must be based upon results of the performance tests described in the next chapter. You must use your judgment in applying this requirement. Obviously, it should not be applied unless a majority of pumps are over registering and unless the cumulative effect of these overregistration is likely to significantly benefit the owner. In doubtful cases, the past compliance history should be considered. The readability and accuracy of reading the test measure also needs to be taken into account. Many jurisdictions have established guidelines or policies within their own

jurisdictions for applying the maintenance of equipment requirement. These guidelines or policies help to ensure that the inspectors in their jurisdiction are applying the requirement consistently and uniformly.

Procedures for inspecting the readability of indicating elements and the condition of the discharge hose are described below. The accuracy of the measuring device and the discharge nozzle are tested in a later segment. Thus, a thorough inspection should be made:

- for broken glass covering the indicating elements; and
- for leaks inside the dispenser cabinet.

MARKING REQUIREMENTS

All retail motor-fuel devices are required to be marked with information that identifies the manufacturer or distributor of the device, the model or design, and (for all devices manufactured, sold, or rebuilt after January 1, 1968) a nonrepetitive serial number. For devices manufactured, sold, or rebuilt after certain dates as defined in G-S.1 (see below), the model designation and serial number must be prefaced with terms clearly identifying these designations. In addition, nonretroactive and effective as of January 1, 2003, devices covered under an NTEP Certificate of Conformance (CC) must be marked with the NTEP CC number. The purpose of these marking requirements is to make it possible for the inspector, the manufacturer, and the device owner to monitor the equipment while it is in service, to obtain technical information necessary to determine compliance with regulations, and effect repairs or adjustments when they are required.

The required information must be permanently marked. This means that it must not be removable or alterable, unless provision is made that removal or alteration will be readily evident. Most manufacturers use a thin metal plate upon which the identifying information is etched. This plate should be attached in some way that prevents its being removed without being mutilated or destroyed. For example, rivets might be used to attach the plate, but removable screws would be inappropriate. This is required to prevent the identification plate from being replaced or transferred to another device. To prevent alteration of the information imprinted on it, the plate itself may be made of some pressure-sensitive material. This may cause some problem when the plate is affixed in a position where it is exposed to accidental wear during operation (for example, when it is attached near the discharge nozzle). Repeated abrasion by metal objects may result in accidental obliteration of markings on pressure-sensitive materials.

In general, it is the proprietor's responsibility to assure that identifying markings are accessible after installation and positioned in such a way as to minimize the risk of accidental damage. The information required by G-S.1. may be located inside the dispenser cabinet, provided that it can be observed without dismantling that requires the use of a tool.

Note the nonretroactivity of subparagraphs (d), (e), and (f), indicated by italic print and the appended notes. These requirements were made nonretroactive and have been maintained as such, despite the passage of time, because requiring manufacturers to supply nonrepetitive serial numbers for equipment already in existence would have imposed an excessive burden.

As of January 1, 2002, remanufactured devices and remanufactured main elements must also be marked with the name, initials, or trademark of the last remanufacturer or distributor as required by paragraph G-S.1.1. The remanufacturer’s or distributor’s model designation must also be marked on the device if it is different than the original model designation.

G-S.1. Identification. - All equipment, except weights and separate parts necessary to the measurement process but not having any metrological effect, shall be clearly and permanently marked for the purposes of identification with the following information:

(a) the name, initials, or trademark of the manufacturer or distributor;

(b) a model designation that positively identifies the pattern or design of the device;

(c) the model designation shall be prefaced by the term "Model," "Type," or "Pattern." These terms may be followed by the term "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.). The abbreviation for the word "Model" shall be "Mod" or "Mod."
[Nonretroactive January 1, 2003]
(Added 2000) (Amended 2001)

*[**Note:** Prefix lettering may be initial capitals, all capitals or all lower case.]*

(d) except for equipment with no moving or electronic component parts, a nonrepetitive serial number;
[Nonretroactive as of January 1, 1968]

(e) the serial number shall be prefaced by words, an abbreviation, or a symbol, that clearly identifies the number as the required serial number; and
[Nonretroactive as of January 1, 1986]

(f) the serial number shall be prefaced by the words "Serial Number" or an abbreviation of that term. Abbreviations for the word "Serial" shall, as a minimum, begin with the letter "S," and abbreviations for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., S/N, SN, Ser. No, and S No.).
[Nonretroactive as of January 1, 2001]

(g) For devices that have an NTEP Certificate of Conformance (CC) Number or a corresponding CC addendum number, the NTEP CC shall be prefaced by the terms "NTEP CC," "CC," or "Approval." These terms may be followed by the term "Number" or an abbreviation of that word. The abbreviation for the word "Number" shall, as a minimum, begin with the letter "N" (e.g., No or No.)
[Nonretroactive as of January 1, 2003]

The required information shall be so located that it is readily observable without the necessity of the disassembly of a part requiring the use of any means separate from the device.
(Amended 1985, 1991, 1999 and 2000)

G-S.1.1. Remanufactured Devices and Remanufactured Main Elements. - All remanufactured devices and remanufactured main elements shall be clearly and permanently marked for the purposes of identification with the following information:

(a) the name, initials, or trademark of the last remanufacturer or distributor;

(b) the remanufacturer's or distributor's model designation if different than the original model designation.
[Nonretroactive as of January 1, 2002]
(Added 2001)

Note: Definitions for "manufactured device," "repaired device," and "repaired element" are also included (along with definitions for "remanufactured device" and "remanufactured element") in Appendix D, Definitions.

Effective and nonretroactive as of January 1, 2003, the required marking information specified in G-S.1. must appear in a specific location on retail motor-fuel dispensers, as specified in paragraph S.4.4.2. of the Liquid-Measuring Devices Code. The information must be placed on a portion of the device that cannot be readily removed or interchanged without a tool separate from the device. The information shall appear 24 to 60 inches from the base of the dispenser, either on the outside of the device or behind an access door or panel.

S.4.4.2. Location of Marking Information; Retail Motor-Fuel Dispensers. - The required marking information in the General Code, Paragraph G-S.1. shall appear as follows:

(a) Placement of this information shall not be on a portion of the device that can be readily removed or interchanged without the use of a tool separate from the device.

(b) The information shall appear 24 inches to 60 inches from the base of the dispenser when placed on the outside of the device.

(c) When placed behind an access door or panel the information shall appear 24 inches to 60 inches from the base of the dispenser in a readily legible position. The use of a dispenser key shall not be considered a tool separate from the device.
[Nonretroactive as of January 1, 2003]

(Added 2002)

In addition to the information described above, any limitations that apply to the use of the device must also be clearly and permanently marked. For example, some dispensers are designed to measure specific products (like diesel fuel), or are only accurate when operated at specific flow rates. Also, if the device is only compatible with specified remote or auxiliary equipment such as consoles or ticket printers, these specifications must be displayed.

S.4.1. Limitation on Use. - The limitations on its use shall be clearly and permanently marked on any device intended to measure accurately only:

(a) products having particular properties; or

(b) under specific installation or operating conditions; or

(c) when used in conjunction with specific accessory equipment.

Additional marking requirements apply to high-speed retail motor-fuel dispensers such as those used at truck refueling stations. Effective January 1, 1985, Liquid-Measuring Devices Code paragraph S.4.4.1. requires that retail devices designed with a maximum discharge rate of 115 L (30 gal) per minute or greater, be marked on an exterior surface of the device visible after installation with:

- the maximum discharge rate and

- the minimum discharge rate.

In addition, the minimum discharge rate shall not exceed 20 percent of the maximum discharge rate. For example, a device with a marked maximum discharge rate of 50 gallons per minute (gpm) cannot have a minimum discharge rate greater than 10 gpm since 10 gpm is 20 percent of 50 gpm. Thus, a marked minimum discharge rate of 20 gallons per minute would be unacceptable. The purpose of this requirement is to ensure that a meter is designed and manufactured to be accurate over a reasonably wide range of flow rates.

S.4.4.1. Discharge Rates. - On a retail device with a designed maximum discharge rate of 115 L (30 gal) per minute or greater, the maximum and minimum discharge rates shall be marked on an exterior surface of the device and shall be visible after installation. The minimum discharge rate shall not exceed 20 percent of the maximum discharge rate.
[Nonretroactive as of January 1, 1985.]
(Added 1984)(Amended 2002)

Some stations use "self-pay" equipment. In these installations the customer pays for his or her purchase by inserting a credit card or money into the device itself. For a money-operated self-pay device, the name, address, and phone number of the person or agency responsible for returning money paid when the dispenser does not deliver the fuel purchased or malfunctions in some other way, must be displayed, either on the device itself, or in a position immediately adjacent to the device. Where employees are present and responsible for resolving any money discrepancies with the customer, this posting requirement is not applicable.

G-UR.3.4. Responsibility, Money-Operated Devices. - Money-operated devices other than parking meters shall have clearly and conspicuously displayed thereon, or immediately adjacent thereto, adequate information detailing the method for the return of monies paid when the product or service cannot be obtained. This information shall include the name, address, and phone number of the local responsible party for the device. This requirement does not apply to devices at locations where employees are present and responsible for resolving any monetary discrepancies for the customer. (Amended 1977, 1993)

Finally, note that G-UR.2.1.1., discussed above under **Installation**, requires that the dispenser must be installed in such a way that all required markings, including those described in this section, are readily observable.

Locate the device identification plate and inspect it for position, damage, and readability. You should also determine that all required items of information are displayed.

If additional marking requirements apply (for discharge rates, use limitations, or operating information) determine that all specified information is clearly and prominently displayed. If you suspect that use limitations may apply but are not displayed, first consult the operator of the device, then contact the device manufacturer or distributor if necessary. In general, your best guide will be your past experience with equipment of similar design.

INDICATING AND RECORDING ELEMENTS

Design

As you learned in Chapter 3, indicating elements (either at the dispenser or at a console) produce temporary readings of the quantity of product delivered and the price computed automatically for that delivery. Recording elements (like a ticket or receipt printer) provide readings that are permanent. In both cases, the "readings" are produced directly by the operation of the measuring element (the meter). A primary indicating or recording element is one that is designed to be, or is, used in the normal commercial use of the device. Primary elements are thus those that are actually used —either by the customer or the operator —to determine the quantity delivered and the price of that quantity. The indicator on the pump itself is, of course, a primary element, and in some installations this might be the only primary element. But, if a remote readout is used by the operator to determine the quantity and price of the delivery—for example, at a control console—this would also be a primary device. An automatic ticket printer would be considered a primary recording element. A totalizer, however, would not normally be considered a primary element, since it is usually not used to determine the amount or price of an individual sale.

S.1.1. General. - A liquid-measuring device:

(a) shall be equipped with a primary indicating element, and

(b) may be equipped with a primary recording element.

The need for a primary indicating element is obvious: it provides the only basis for a transaction in which both seller and buyer are informed. Primary recording elements, on the other hand, are often just a convenience to the operator and the proprietor and to the customer, and so are not always required. Recorded representations are required for devices activated by debit cards, credit cards, and/or cash; these requirements will be discussed later in this Chapter under paragraph S.1.6.7. Recorded Representations. The units in which quantities must be indicated and recorded are also specified in paragraph S.1.2.

Quantities of product are required to be indicated in gallons or liters and fractions or decimal subdivisions of these units to avoid any confusion on the part of the motorist, to whom these units are "standard". Most consumers will not even think to look at the units, and so might be easily misled by a pump indicating in quarts, for example.

S.1.2. Units. - A liquid-measuring device shall indicate, and record if the device is equipped to record, its deliveries in liters, gallons, quarts, pints, or binary-submultiples or decimal subdivisions of the liter or gallon. (Amended 1987, 1994)

S.1.2.1. Retail Motor-Fuel Devices. - Deliveries shall be indicated and recorded, if the device is equipped to record, in liters or gallons and decimal subdivisions or fractional equivalents thereof. (Added 1979)

S.1.2.3. Value of Smallest Unit. - The value of the smallest unit of indicated delivery, and recorded delivery if the device is equipped to record, shall not exceed the equivalent of:

(a) 0.5 L (1 pt) on retail devices;

(b) 5 L (1 gal) on wholesale devices.

This requirement does not apply to manually operated devices equipped with stops or stroke-limiting means. (Amended 1983 and 1986)

Retail motor-fuel devices are required to indicate deliveries in units that are the equivalent of one pint or smaller. Dispensers that indicate decimal gallons will automatically meet this requirement, since one pint = 0.125 gal. Note, however, that a separate requirement (S.1.6.5.2., described under **Money Value Divisions**, below) requires the smallest unit of delivery for digital devices to be no greater than 0.01 gallon.

Compliance with requirements under this heading can generally be determined by visual inspection, without opening the dispenser cabinet. You should:

1. Identify all primary indicating and recording elements, keeping in mind that remote elements can be primary elements for a particular dispenser, even if they are shared by other dispensers.

2. For each primary element identified, observe the units and denominations used, see Figure 5-2 on the following page. These should be gallons (or liters), with the smallest subdivision equivalent to one pint or less.

It will probably be impossible by this cursory inspection to detect mechanical or electronic modifications that have been made deliberately, with the intention of advancing indicating or recording elements beyond the final amount indicated during delivery. Such modifications are illegal, and the perpetrator will have made some effort to conceal them. If complaints have been received, or if you have any other reason to suspect such tampering, notify your supervisor and seek his or her guidance regarding further testing.

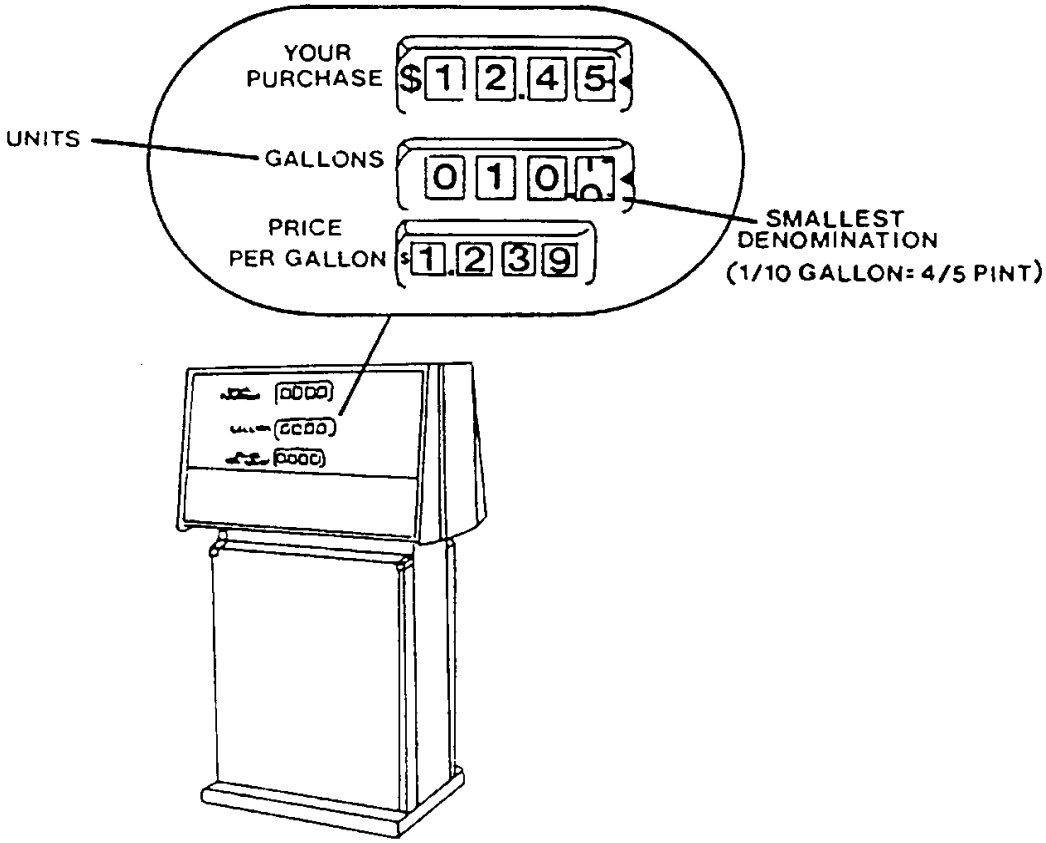


FIGURE 5-2. UNITS INDICATED

Readability

To avoid errors and the possibility of misrepresentation, the customer, as well as the operator, must be able to read and understand the information provided by primary indicating and recording elements. The general and specific requirements quoted below are intended to ensure this. Specifications are made regarding the size, uniformity, and durability of indicators using either analog or digital representations.

The extensive and increasing use of self service makes it essential that operating controls as well as indicators be clearly identified for customers whose knowledge and experience may be limited. This is especially important for installations that use "shared electronics," as does the system pictured in Figure 5-3, where a single digital readout serves three dispenser hoses, each of which delivers a different product. It must always be clear what product is being delivered from any hose that is in operation. Note in Figure 5-3 the arrow indicating that the $1.159 per gallon product was delivered, and the corresponding mathematical agreement of unit price, total quantity and total sale for the indicated unit price of this transaction.

Section G-S.5. of the General Code sets forth a number of requirements that apply generally to indicating and recording elements for all types of weighing and measuring devices. (Only those requirements in G-S.5. that relate specifically to readability have been quoted on the next page of text.)

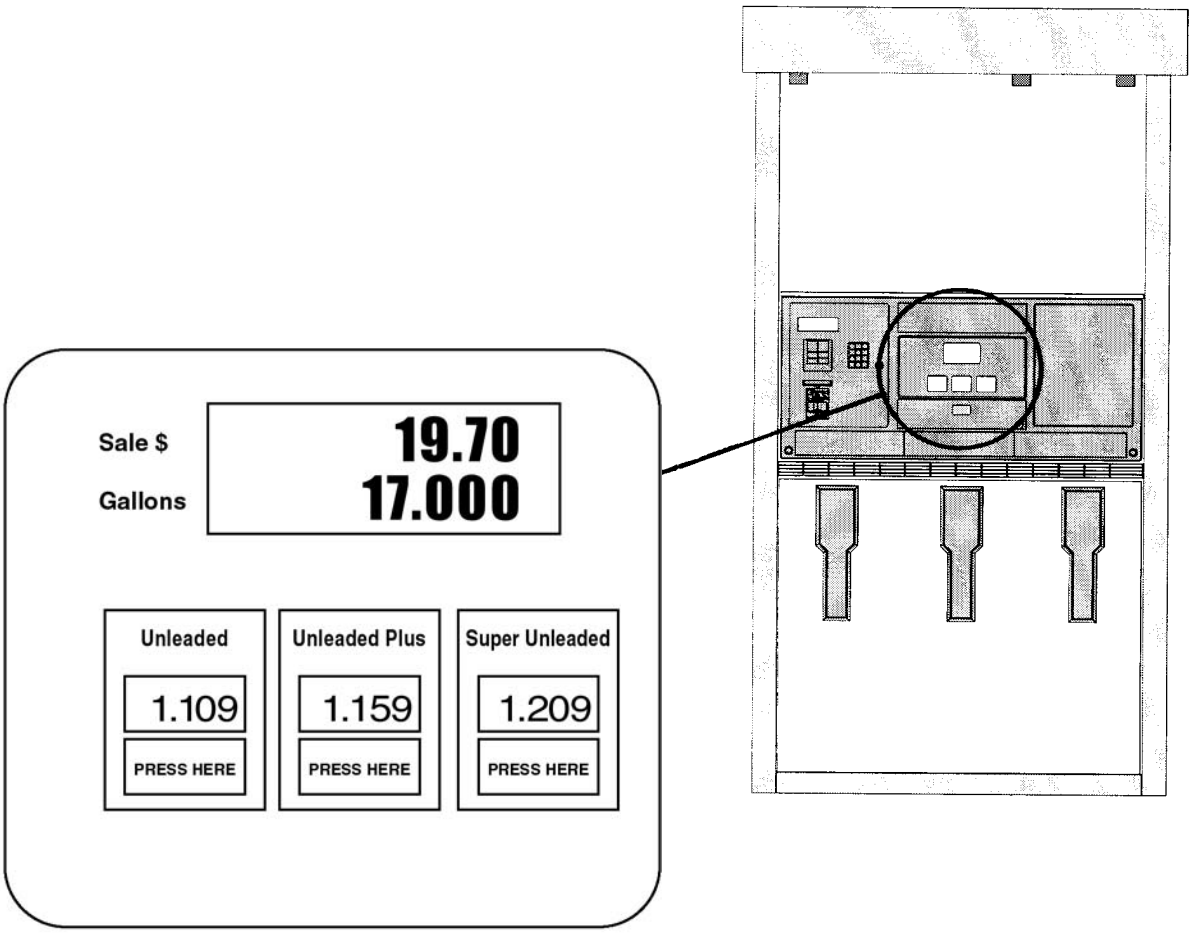


FIGURE 5-3. MULTI-PRODUCT DISPENSER GROUP WITH SHARED ELECTRONICS

Requirements in the LMD Code, which are described below, specify in some detail design features that are appropriate for retail motor-fuel devices. Note in G-S.5.1. the requirement that indications and recorded representations must be "clear, definite, accurate, and easily read under any conditions of normal service..."

Some mechanical gas pumps have subordinate graduations midway between the major, marked intervals on the right hand indicating wheels, that is, marking intervals of one-half cent and 0.05 gallon. These are useful for visual rounding of values, but are not required. However, in accordance with G-S.5.2.3., the subordinate character of these graduations must be clear. They should be distinctly different in length and/or thickness from the whole-unit graduations. If they are marked by numbers (they usually are not), the numbers should clearly and unambiguously reflect that they are subdivisions of major graduated intervals.

Explanatory words, figures, and symbols (see G-S.5.2.4.) must be used with indications or recorded representations associated with gas pumps to clearly identify their intended values. Appropriate designations of the units such as gallons, gal, liter, L, and $ are used to denote units of measure and money.

G-S.5. Indicating and Recording Elements.

G-S.5.1. General. - All weighing and measuring devices shall be provided with indicating or recording elements appropriate in design and adequate in amount. Primary indications and recorded representations shall be clear, definite, accurate, and easily read under any conditions of normal operation of the device.

G-S.5.2. Graduations, Indications, and Recorded Representations.

* * *

G-S.5.2.3. Size and Character. - In any series of graduations, indications, or recorded representations, corresponding graduations and units shall be uniform in size and character. Graduations, indications, or recorded representations that are subordinate to or of a lesser value than others with which they are associated shall be appropriately portrayed or designated. (Made retroactive as of January 1, 1975)

G-S.5.2.4. Values. - If graduations, indications, or recorded representations are intended to have specific values, these shall be adequately defined by a sufficient number of figures, words, symbols, or combinations thereof, uniformly placed with reference to the graduations, indications, or recorded representations and as close thereto as practicable, but not so positioned as to interfere with the accuracy of reading.

G-S.5.2.5. Permanence. - Graduations, indications, or recorded representations and their defining figures, words, and symbols shall be of such character that they will not tend easily to become obliterated or illegible.

G-S.5.6. Recorded Representations. - Insofar as they are appropriate, the requirements for indicating and recording elements shall be applicable also to recorded representations. All recorded values shall be printed digitally. (Amended 1975) (Made retroactive 1990)

Indicators are usually (though not always) protected by a glass or plastic face plate. Manufacturers must design devices so that their graduations, indications, recorded representations, and their defining figures, words, and symbols will not tend to easily become illegible. In the case of recorded representations (receipts, delivery tickets, invoices, etc.), permanent ink should be used. Requirements for indicating and recording elements apply, wherever appropriate, to such printed records of a transaction, according to G-S.5.6., which states, in addition, that recorded representations must be digital: that is, it must use numbers. For example, a sales receipt bearing a printed representation of the dispenser's graduated indicating wheels with a pointer would not meet this requirement.

Additional requirements in the General Code relate to required markings, including those used to identify the device and its limitations of use (described previously in the section on **Marking**), and also to markings used to identify controls, and to instructions. In accordance with G-S.6. and G-S.7., if a dispenser is equipped with push buttons for selecting cash or credit method of payment, they would have to be clearly identified, for example, by lettering (G-S.6.). If the dispenser is self-service, instructions would also have to be provided to direct the customer to make the cash/credit selection before operating the pump (see Figure 3-18 for an illustration of these controls and markings). The markings would have to be readable and permanent (G-S.7.).

Specific requirements relating to the size, proportion, and spacing of graduations and their indicators (for gas pumps, the fixed pointers adjacent to the right-hand quantity and total price wheels) are included in the LMD Code. (Obviously, these requirements do not apply to electronic displays, which do not have graduations.)

G-S.6. Marking Operational Controls, Indications, and Features. - All operational controls, indications, and features, including switches, lights, displays, push buttons, and other means, shall be clearly and definitely identified. The use of approved pictograms or symbols shall be acceptable. [Nonretroactive as of January 1, 1977.] (Amended 1978, 1995)

G-S.7. Lettering. - All required markings and instructions shall be distinct and easily readable and shall be of such character that they will not tend to become obliterated or illegible.

For a routine field examination it is neither practical nor necessary to check each of the specified measurements set forth in paragraphs S.1.4 and S.1.5 (quoted on the next page). If indications are clearly readable from a "reasonable customer position" and are not obviously outside the limitations, the inspector may presume that the requirements are met.

All primary indicating and recording elements should be observed, with special attention paid to dirt or grease, damage, or wear that might obscure indicators or identifying letters or diminish their readability under normal operating conditions. If you suspect that nonapproved modifications have been made, consult your supervisor for guidance.

S.1.4. Graduations

S.1.4.1. Length. - Graduations shall be varied in length so that they may be conveniently read.

S.1.4.2. Width. - In a series of graduations, the width of:

(a) every graduation shall be at least 0.008 inches but not greater than the minimum clear interval between graduations, and

(b) main graduations shall be not more than 50 percent greater than the width of subordinate graduations.

S.1.4.3. Clear Interval Between Graduations. - The clear interval between graduations shall be not less than 0.04 inch. If the graduations are not parallel, the measurement shall be made:

(a) along the line of movement of the tip of the index of the indicator as it passes over the graduations, or

(b) if the indicator extends over the entire length of the graduations, at the point of widest separation of the graduations.

S.1.5. Indicators.

S.1.5.1. Symmetry. - The portion of the index of an indicator associated with the graduations shall be symmetrical with respect to the graduations.

S.1.5.2. Length.

(a) If the indicator and the graduations are in different planes, the index of the indicator shall extend to each graduation with which it is to be used.

(b) If the indicator is in the same plane as the graduations, the distance between the index of the indicator and the ends of the graduations, measured along the line of the graduations, shall be not more than 0.04 inch.

S.1.5.3. Width.

(a) The index of an indicator shall not be wider than the width of the narrowest graduation. [Nonretroactive as of January 1, 2002.]
(Amended 2000)

(b) If the index of an indicator extends over the entire length of a graduation, it shall be of uniform width throughout the portion that coincides with the graduation.

S.1.5.4. Clearance. - If the indicator and the graduations are in different planes, the clearance between the index of an indicator and the plane of the graduations shall be no greater than 0.06 inch.

S.1.5.5. Parallax. - Parallax effects shall be reduced to the practical minimum.

Values of Intervals

For analog devices, a graduated interval is the distance from the center of one graduation to the center of the next graduation in the series, as illustrated in Figure 5-4.

This interval represents a certain value, in the example shown in Figure 5-4, this value is one-tenth of a gallon. This value must be uniform throughout the series. Again in the example shown, the passage of the indicator across the graduated interval must always represent one-tenth of a gallon.

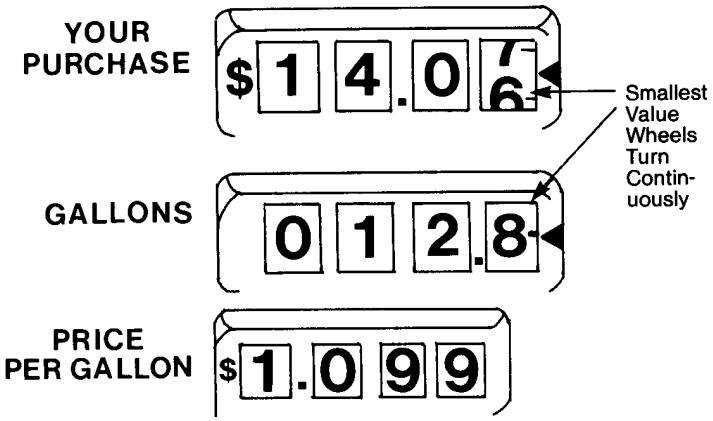


FIGURE 5-4. GRADUATED INTERVALS

G-S.5.3. Values of Graduated Intervals or Increments. - In any series of graduations, indications, or recorded representations, the values of the graduated intervals or increments shall be uniform throughout the series.

G-S.5.3.1. On Devices that Indicate or Record in more than One Unit. - On devices designed to indicate or record in more than one unit of measurement, the values indicated and recorded shall be identified with an appropriate word, symbol, or abbreviation. (Amended 1978 and 1986) (Made retroactive 1990)

For digital indicators, the increment corresponds to the value of the graduated interval. The increment is the smallest change in value that can be recorded or indicated. For example, consider a digital indicator that is capable of displaying hundredths of a gallon. If at the beginning of a delivery the first indicated quantity is 0.01 gal, the next 0.02 gal, the next 0.03 gal, and so on, the increment is 0.01 gal. However, if the first indicated quantity is 0.02 gal, the next 0.04 gal, the next 0.06 gal, etc., the increment is 0.02 gal—the smallest change that can be displayed.

For devices that are capable of indicating and/or recording both U.S. inch-pound and metric units, either mode can be used provided that the units are clearly labeled and that the customer has all the information necessary to understand the transaction. This option has been allowed in order not to discourage conversion to the metric system.

Most motor-fuel devices with analog indicators utilize revolving quantity and price wheels driven by a mechanical computer (as described in Chapter 3). The uniformity of values represented by graduated intervals can be observed directly on these wheels without operating the device if the wheels can be exposed: if the graduated intervals are equal and the difference between each pair of successive values is equal, the values are uniform.

To test a digital indicator would require observing indications through an entire cycle (10,000 or more individual indications!) or dismantling of the device and use of special test equipment. Such tests can not practically be performed in the field.

For a routine examination, and in the absence of complaints or other evidence pointing to tampering or unapproved modifications, you may be satisfied by spot checking the agreement of quantity and price indications with mathematical computations for several different indicated values. This technique is described in Chapter 6.

Indication of Delivery

The indicator must display the quantity throughout the delivery, from an initial zero to the final quantity.

> **S.1.6.1. Indication of delivery.** - The device shall automatically show on its face the initial zero condition and the quantity delivered (up to the nominal capacity).
>
> However, the first 0.009 gallon (or 0.03 liter) of a delivery and its associated total sales price need not be indicated.

The allowance that the first 0.009 gallon (or 0.03 liter) and its associated sales price need not be indicated is intended for digital indicators that have a smallest unit of indicated delivery of less than 0.01 gallon. It permits suppression of the indication of a small quantity (0.009 gallon is slightly more than 2 cubic inches) and its associated price (slightly more than 1 cent at a unit price of $1.25/gal) when the dispenser is switched on. As will be explained in detail in Chapter 6 (under Normal Test), this small amount is usually due to "computer jump," which occurs normally under certain operating conditions in this type of equipment.

Note that only the display of this quantity may be suppressed, not the registration: both the quantity and price must be included in the total delivery. In effect, this allowance simply permits such a device to display zero indications until 0.009 gal or 0.03 liter has been delivered. Since computer jump normally occurs between the time the dispenser is switched on and the time the discharge valve is opened, suppression of the indicated values avoids confusion and misunderstanding on the part of the customer.

Because compliance with S.1.6.1. can only be verified by operating the dispenser, the EPOs also cite this paragraph under the Test. Again, see Chapter 6 for additional discussion.

Money-Value Divisions

The money-value division is the smallest computed price that can be indicated. For analog indicating devices, this is equivalent to the value of the graduated interval that represents the smallest price (usually on the cents wheel, see Figure 5-5). For digital indicators, it is the smallest increment of price that can be displayed. In earlier versions of electronic dispensers the volume indication was 0.01 gallons and there were unit price selections where the total sale for some volumes delivered would increment in $0.02 intervals. Today, with the exception of some dispensers where the unit price is less than $1.00 per gallon, there will be few occasions

where you will encounter a digital electronic dispenser indicating in 0.01 gallons. With modern electronic dispensers which indicate in 0.001 gallons the money value division and money value increment will be the same up to a unit price of $9.999. A typical electronic display is shown in Figure 5-6.

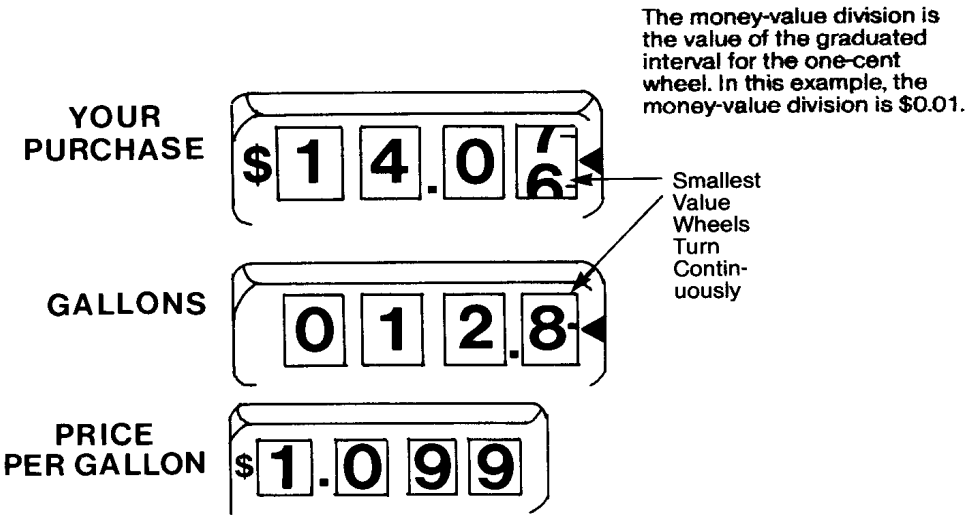


FIGURE 5-5. MONEY-VALUE DIVISIONS MECHANICAL ANALOG INDICATOR

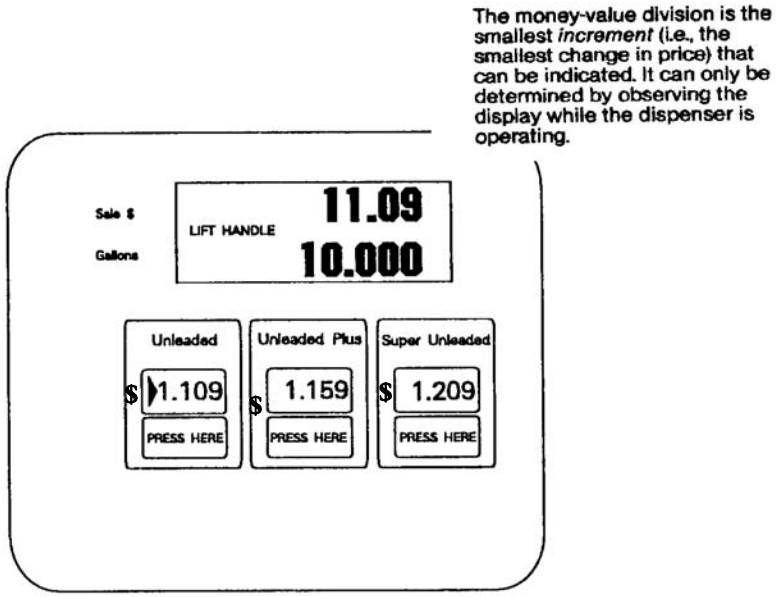


FIGURE 5-6. MONEY-VALUE DIVISIONS ELECTRONIC DIGITAL INDICATOR

In the late 1970s the price of gasoline exceeded $1.00 per gallon. Mechanical computers in use at that time could not compute at unit prices above $0.999 per gallon. The price rise happened so quickly that industry could not respond fast enough with new equipment to meet the market place needs. Stop gap measures gave industry time to respond and Handbook 44 was amended to allow money value divisions as can be seen in paragraph S.1.6.5.1. and Table 1. Had prices continued to spiral as predicted, the amendment and greater money value divisions of $0.02 and $0.05 would have been needed. With the increase in the number of electronic devices in use there is only a remote possibility that we will see a proliferation of $0.02 and $0.05 unit price divisions on mechanical computers. As inspectors, however, you need to be aware of the Handbook 44 provision for this eventuality.

S.1.6.5.1. Money-Value Divisions, Analog. - The values of the graduated intervals representing money values on a computing type device shall be those in Table 1. (Amended 1991)

Table 1.
Money-Value Divisions and
Maximum Allowable Variations for Money-Value
Computations on Mechanical Analog Computers

Unit Price		Money Value Division	Maximum Allowable Variation	
From	To and including		Design Test	Field Test
0	0.25/liter or $1.00/gallon	1¢	± 1¢	± 1¢
0.25/liter or $1.00/gallon	0.75/liter or $3.00/gallon	1¢ or 2¢	± 1¢	± 2¢
0.75/liter or $3.00/gallon	2.50/liter or $10.00/gallon	1¢ or 2¢	± 1¢	± 2¢
0.75/liter or $3.00/gallon	2.50/liter or $10.00/gallon	5¢	± 2 1/2¢	± 5¢

Money-value divisions for digital devices are not specified in the same way as they are for analog devices. In accordance with S.1.6.5.2., they are a function of the quantity-value increment and the unit price.

S.1.6.5.2. Money-Value Divisions, Digital. - A computing type device with digital indications shall comply with the requirements of paragraph G-S.5.5. Money Values, Mathematical Agreement, and the total price computation shall be based on quantities not exceeding 0.01-gallon intervals for devices indicating in inch-pound units and 0.05 liter for devices indicating in metric units. (Added 1980)

While Handbook 44 allows digital, quantity-value increments of 0.01 gallon, few retail motor fuel dispensers remain in service with 0.01 increments. Most, if not all, dispensers placed in service over the past several years

have 0.001 gallon quantity-value increments. However, the following is offered to give some explanation of situations encountered at various unit prices for equipment with quantity-value increments of 0.01 gallon.

For a given dispenser, the money-value division will thus vary with the unit price. For example, consider a digital indicator whose quantity-value increment is 0.01 gal. If the unit price is $1.00/gal, the following progression of money-values would be displayed:

Quantity		Price
1.00 gal		$1.00
1.01	@ $1.00/gal	$1.01
1.02		$1.02

The money-value division in this example would, thus, be $0.01. However, if the unit price is changed to $1.50/gal, the following progression would occur:

Quantity		Price
1.00 gal		$1.50
1.01	@ $1.50/gal	$1.52 ($1.515 rounded up)
1.02		$1.53
1.03		$1.55 ($1.545 rounded up)

In this example, the money-value division could be considered to be $0.015 (the unit price times the quantity increment). However, the effective money-value division is either $0.01 or $0.02, because the increment is always rounded to the nearest whole cent. If the unit price is changed again, this time to $2.00/gal, the money-value division will then be $0.02 (the quantity increment times the unit price).

An effective money-value division of more than 1 cent will obviously cause some problem if the customer wants to purchase a dollar amount of gas that cannot be displayed (for example, in the last example shown above the pump would not be capable of displaying a sale of exactly $1.51 worth of product). This problem is avoided if the dispenser is designed to display quantity increments of thousandths of a gallon, since the money-value division will then not exceed 1 cent for any unit price up to $10.00/gal.

(Note that a digital device must also comply with paragraph G-S.5.5., according to which any money value displayed must agree with the mathematically computed value to the nearest one cent of money value. This requirement will be described in the next chapter, under **Test Notes**.)

If the dispensing system is equipped with auxiliary indicating or recording elements, such as a control console, paragraph S.1.6.5.3. requires that the money-value divisions on the auxiliary indicator be the same as on the primary element.

> ***S.1.6.5.3. Auxiliary Elements.*** *- If a system is equipped with auxiliary indications, all indicated money-value divisions of the auxiliary element shall be identical with those of the primary element. [Nonretroactive and enforceable as of January 1, 1985.]*

For example, if a dispenser with an analog indicator has money-value divisions of $0.02, the money-value divisions of the digital control console must also be $0.02.

Because inspection of the money-value divisions for a digital dispenser requires operating the device and observing computed values, the most efficient way of performing this procedure is during the Test, when related procedures are performed with the system in operation as described in Chapter 6. Chapter 6 also describes the requirements of S.1.6.6. Agreement Between Indications, which addresses the agreement between the indications on the console (or other auxiliary element) and the retail motor-fuel dispenser.

Unit Price and Product Identity

The customer must be provided with the basic information required to select the product he or she wishes to purchase; consequently, the LMD Code includes several requirements intended to ensure that this information is available and is displayed prominently and conspicuously. Subparagraph S.1.6.4.1.(a) requires that the unit price at which the device is set to compute or dispense be displayed by the device. When a dispenser is designed to be operated from either side of a service island, this information must be displayed on each face of the device. [The LMD Code makes a distinction between the "face" and the "side" of a device. The "side" is that part of the device that faces the consumer during normal delivery. The "face" is that part of the device that displays the computation of the price per unit, delivered quantity, and total sale price; in some electronic systems, the face may be separate from the pump or dispenser.]

S.1.6.4.1. Unit Price

(a) A computing or money-operated device shall be able to display on each face the unit price at which the device is set to compute or to dispense.

* * *

S.1.6.4.2. Product Identity

(a) A device shall be able to conspicuously display on each side the identity of the product being dispensed.

(b) A device designed to dispense more than one grade, brand, blend, or mixture of product also shall be able to display on each side the identity of the grade, brand, blend, or mixture being dispensed.

Subparagraph S.1.6.4.2.(a) requires that a device must be able to display on each side the identity of the product being dispensed (e.g., the grade, brand, blend, or mixture) while subparagraph S.1.6.4.2.(b) requires that if a device is designed to dispense more than one subcategory of product (e.g., different grades, brands, etc.) it must be able to display on each side the identity of each product or blend of product available from that dispenser.

The LMD Code also includes a user requirement, which requires the owner or operator of the dispenser to provide and maintain the correct information.

Note that UR.3.2.(a) states that it is not necessary for unit prices for all grades, brands, blends, or mixtures available from a dispenser to be displayed simultaneously, provided that the dispenser complies with S.1.6.4.1. [this reference relates to the special requirement for multiple unit price dispensers in S.1.6.4.1.(b), which is discussed below under the heading **Multiple Unit Price Dispensers.**]

Inspect each side and face of each dispenser to determine compliance with the unit price and product identity requirements.

UR.3.2. Unit Price and Product Identity.

(a) The following information shall be conspicuously displayed or posted on the face of a retail dispenser used in direct sale:

(1) except for dispensers used exclusively for fleet sales, other price contract sales, and truck refueling (e.g., truck stop dispensers used only to refuel trucks), all of the unit prices at which the product is offered for sale; and

(2) in the case of a computing type or money-operated type, the unit price at which the dispenser is set to compute.

Provided that the dispenser complies with S.1.6.4.1., it is not necessary that all the unit prices for all grades, brands, blends, or mixtures be simultaneously displayed or posted.

(b) The following information shall be conspicuously displayed or posted on each side of a retail dispenser used in direct sale:

(1) the identity of the product in descriptive commercial terms, and

(2) the identity of the grade, brand, blend, or mixture that a multi-product dispenser is set to deliver.

(Amended 1972, 1983, 1987, 1989, 1992, and 1993)

Advancement and Return to Zero

In most gas stations, the transaction between buyer and seller occurs at the time when the product is delivered to the vehicle's tank. To protect the consumer and assure an accurate basis for the sale, all primary indicating and recording elements must be reset to zero before each delivery begins. In addition, it must not be possible to return indicating or recording elements past their zero indication, since to do so, either by accident or design, would result in an indication of more product than had actually been delivered.

Section S.1.6.3 of the LMD Code requires that retail motor-fuel dispensers be equipped with means to reset primary indicating and recording elements to zero between deliveries.

In most cases, the quantity and price indicated when the transaction is concluded represent a single delivery of product. However, certain self-operated devices, such as those that use key locks and card acceptors, permit individual customers to purchase fuel through specially equipped dispensers. The user has a key or coded card which must be inserted to actuate the dispenser. Payment is commonly made monthly and based upon totals from cumulative indicating or recording elements, called totalizers, which are assigned individually to customers. In addition to these elements, self-operated pumps are required to be equipped with elements that can be returned to zero. This allows the customer to determine the amount and cost of a purchase at the time of delivery, without having to record beginning and ending readings from the totalizers.

S.1.3. Advancement of Indicating and Recording Elements. - It shall not be possible to advance primary indicating and recording elements except by the mechanical operation of the device. Clearing a device by advancing its elements to zero is permitted, but only if:

(a) once started, the advancement movement cannot be stopped until zero is reached, and

(b) in the case of indicating elements only, such elements are automatically obscured until the elements reach the correct zero position.

The advancement of indicating and recording elements is required to be accomplished by operation of the dispenser—that is, only while fuel is actually being delivered. This requirement (S.1.3.) helps insure that no amount other than that actually delivered can be indicated, either by accident or as the result of tampering (although this, by itself, is not sufficient, since metering or computing components that do not function correctly can effectively nullify this assurance). However, mechanical indicating and recording elements are usually reset by turning the individual digits forward, that is, by advancing them.

Paragraph S.1.3. does permit a retail motor-fuel device to be cleared by advancing its indicating elements to zero, provided that the movement cannot be stopped until it has reached zero, and that all indications are obscured until the element reaches zero. These provisions help to ensure that neither operator nor customer will be able to read or record an amount during the resetting process.

On most electronic indicators, this is accomplished by blanking out the display during the reset. Before displaying zero, however, the figure 8 is displayed momentarily for all digits. This is a test of the display; the figure 8 contains all the independently activated segments that are used to display the other numbers, thus, if all the segments of the 8 appear, all other numbers can be displayed correctly.

Of course, the fact that a dispenser is capable of being reset to zero between deliveries does not assure that it will be. Retail motor-fuel devices are therefore also required to be equipped with interlocking devices, either mechanical or electronic, which automatically reset the dispenser before a delivery is begun.

S.2.5. Zero-Set-Back Interlock, Retail Motor-Fuel Devices. - A device shall be constructed so that:

(a) after a delivery cycle has been completed by moving the starting lever to any position that shuts off the device, an automatic interlock prevents a subsequent delivery until the indicating elements, and recording elements if the device is equipped and activated to record, have been returned to their zero positions;

(b) the discharge nozzle cannot be returned to its designed hanging position (that is, any position where the tip of the nozzle is placed in its designed receptacle and the lock can be inserted) until the starting lever is in its designed shut-off position and the zero-set-back interlock has been engaged; and

(c) in a system with more than one dispenser supplied by a single pump, an effective automatic control valve in each dispenser prevents product from being delivered until the indicating elements on that dispenser are in a correct zero position.
(Amended 1981 and 1985)

Generally, the system is interlocked through the on/off mechanism. Note that subparagraph (b) requires that the dispenser be designed so that the nozzle can not be replaced in the dispenser until this lever is placed in the off position (see Figure 3-17 for an illustration). Note, also, that in systems in which more than one dispenser is supplied by a single pump, the control valves must be interlocked to prevent delivery before resetting.

In the next chapter you will learn how to test the zero-set-back interlock to determine whether or not it is functioning properly.

Unfortunately, all of these safeguards can be circumvented. For example, suppose that an unscrupulous attendant at a busy station makes a relatively small delivery to one motorist, collects the indicated price, and then simply puts the nozzle in the fill pipe of the next vehicle and begins pumping, without turning the dispenser off first. He or she could then charge an unobservant second customer for both deliveries, based upon the indicated quantity at the end of the delivery. The LMD Code includes a user requirement (UR.3.1.) which requires resetting between deliveries for all dispensers for which zero set-back is required by S.1.6.3.

UR.3.1. Return of Indicating and Recording Elements to Zero. - On any dispenser used in making retail deliveries, the primary indicating element, and recording element if so equipped, shall be returned to zero before each delivery.

Exceptions to this requirement are totalizers on key-lock-operated or other self-operated dispensers and the primary recording element if the device is equipped to record.

When inspecting self-operated devices, keep in mind that all indicating and recording elements used by the customer or the operator to determine the amount or price of a delivery are primary elements and must meet the requirements for design, readability, values of intervals, money-value divisions, and unit price and product identity discussed in this section.

Provision for Sealing

Paragraph G-S.8. in the General Code of Handbook 44 requires that an electronic weighing or measuring device be designed so that a security seal can be applied to any electronic adjustable mechanism that affects the measurement capability of the device or that "other approved means" be used to prevent or discourage tampering.

> ***G-S.8. Provision for Sealing Electronic Adjustable Components.*** *- A device shall be designed with provision(s) for applying a security seal that must be broken, or for using other approved means of providing security (e.g., data change audit trail available at the time of inspection), before any change that detrimentally affects the metrological integrity of the device can be made to any electronic mechanism. [Nonretroactive as of January 1, 1990.]*
>
> A device may be fitted with an automatic or a semi-automatic calibration mechanism. This mechanism shall be incorporated inside the device. After sealing, neither the mechanism nor the calibration process shall facilitate fraud.
> (Added 1985)(Amended 1989 and 1993)

For an electronic motor-fuel dispenser, this means that a mechanism, such as a gallon to liter conversion switch, that has a direct impact on the ultimate transaction should be protected in some manner. This usually involves providing a way to attach a physical seal such as a lead-and-wire or pressure sensitive seal; however, manufacturers may now use other approved types of security measures.

One example of another approved means of security is a data change audit trail incorporated in the device's software to make it possible for the weights and measures inspector to determine how many times a particular calibration factor or feature has been accessed since his or her last inspection. Any electronic audit trail used must at a minimum meet three requirements:

- a code or password is needed to access the part of the software that permits access to the operating parameters, features, and accuracy adjustment;
- the system must automatically maintain (even during a power failure) a count of the number of times the calibration or parameter selection software has been accessed and a change(s) made; and
- the device must be equipped with a means by which the enforcement official can easily access this information during an inspection of the device.

While security seals are usually affixed by the weights and measures inspector, a user requirement in the General Code makes it the responsibility of the device owner or operator to make sure that adjustable elements are properly sealed at all times.

> **G-UR.4.5. Security Seal.** - A security seal shall be appropriately affixed to any adjustment mechanism designed to be sealed.

This requirement is also interpreted as requiring that non-physical seals, such as audit trails, be kept operative at all times. Audit trails, as specified in paragraph S.2.2. and Table S.2.2. are discussed in greater detail later in this chapter under the section "Security Seal on Adjustment Mechanism." While audit trails may be used for any sealable parameter, the full discussion seems more appropriate within that section.

Multiple Unit Price Dispensers

Several requirements in the LMD Code relate specifically to multiple unit price dispensers, that is, dispensers which offer a product (or products) at more than one unit price, in contrast to single unit price dispensers, from which products are offered at only one unit price. At the present time, by far the most prevalent application for multiple unit price dispensers is at stations which offer a discount for cash purchases.

When oil companies first instituted discount-for-cash programs, most service stations did not have dispensers that were capable of computing at more than one unit price. Many stations adopted the practice of setting standard dispensers to the higher (credit purchase) unit price, and posting a sign indicating the discount, usually in cents per gallon, for cash purchases. If a customer paid in cash, the attendant would then compute the discount, often manually. If the customer did not notice or understand the sign and did not ask for the discount, an unscrupulous (or simply negligent) attendant could collect the non-discounted sale price. This practice clearly facilitated fraud and constituted use of equipment that was unsuitable to its application.

Dispensers that did have the capability of computing more than one preset unit price were soon available. Typically, the customer selects the method of payment (cash or credit) prior to the delivery; the dispenser then displays the unit price for the selected method of payment and during the delivery computes the total sales price based upon the selected unit price. This type of dispenser has been installed in most new facilities and in many older facilities when equipment was routinely replaced. However, many stations could not afford to replace existing pumps that would not otherwise have needed replacement simply to provide multiple unit pricing capability. At the same time, competitive pressure to participate in discount-for-cash programs was strong. This combination of factors made strict regulation impractical.

In 1989, specific requirements were added to Handbook 44 that were intended to assure that new equipment used in multiple unit price applications would be suitable and would not facilitate fraud. These specifications cover the computing capability, display of unit price, and price selection features of these dispensers. To avoid placing an excessive burden on station owners, these requirements were made nonretroactive. In addition, a user requirement was added to the LMD Code that prohibited placing into service dispensers with only single unit price computing capability in multiple unit price applications after January 1, 1990. This requirement applies to existing equipment as well as new installations. In 1990, another requirement was adopted, which established a date after which all dispensers used in multiple unit price applications would have to have suitable computing capability.

In accordance with S.1.6.4.1.(b), a multiple unit price dispenser must be capable of displaying all unit prices for all grades, brands, blends, or mixtures offered for sale from that dispenser. (S.1.6.4.1.(a), which includes the basic requirement for display of the unit price on any computing or money-operated liquid-measuring device, was discussed above, under **Unit Price and Product Identity.**)

Note that all prices are not required to be displayed simultaneously prior to delivery, provided that the prices can be displayed by using controls that are available to the customer at the dispenser. If, for example, the dispenser is designed so that when the customer presses a cash or credit selector button the unit price for the selected product appears in a display, it would meet the requirement. Note also the exemption for fleet, contract, and truck sales where the unit price is determined by contractual arrangement between the buyer and seller.

New dispensers used in multi-tier pricing applications after January 1, 1991 are also required to have user-operated controls for selecting the unit price.

S.1.6.4. Display of Unit Price and Product Identity.

S.1.6.4.1. Unit Price -

* * *

(b) If a grade, brand, blend, or mixture is offered for sale from a device at more than one unit price, then all of the unit prices at which that product is offered for sale shall be displayed or shall be capable of being displayed on the dispenser using controls available to the customer prior to the delivery of the product. It is not necessary that all of the unit prices for all grades, brands, blends, or mixtures be simultaneously displayed prior to the delivery of the product.
(Effective and nonretroactive as of January 1, 1991.)
(Amended 1989)

S.1.6.5.4. Selection of Unit Price. *- Except for dispensers used exclusively for fleet sales, other price contract sales, and truck refueling (e.g., truck stop dispensers used only to refuel trucks), when a product or grade is offered for sale at more than one unit price through a computing device, the selection of the unit price shall be made prior to delivery using controls on the device or other customer-activated controls. A system shall not permit a change to the unit price during delivery of product.*
[Effective and nonretroactive as of January 1, 1991.]
(Added 1989)(Amended 1991, 1992, 1993, and 1996)

This requirement is intended to eventually eliminate the practice of having the actual selection of a unit price performed by an attendant at a separate console, for example, a practice which could obviously facilitate fraud if the customer did not inform the attendant of a selection (either because the customer did not know that there was a selection to be made or through forgetfulness) or did not verify the selection entered by the attendant.

After January 1, 1991, dispensers must be designed so that the selection of unit price is made at the pump (by the customer) before delivery can begin. Some systems installed prior to 1991 are designed so that if the customer does not make a selection the higher unit price (usually the credit purchase price) is automatically selected and the delivery proceeds. When the customer presents payment, however, the attendant must enter the method of payment, and if this differs from the selection entered prior to delivery, the system will not permit the transaction to be completed electronically until the difference is reconciled. Generally, the system will also recompute the total sale price, based upon the correct unit price, once that has been established. This type of system is not acceptable for new multi-tier pricing installations after January 1, 1991.

Finally, any dispenser in use after January 1, 1999, must also be able to compute the total sale price of deliveries at all unit prices offered from that dispenser (with the exception of fleet, contract, and truck sales).

S.1.6.5. Money-Value Computations.

(a) A computing device shall compute the total sales price at any single-purchase unit price (i.e., excluding fleet sales and other contract sales) for which the product being measured is offered for sale at any delivery possible within either the measurement range of the device or the range of the computing elements, whichever is less.
(Effective and nonretroactive as of January 1, 1991).

Although S.1.6.5.(a), like the other design requirements relating to multiple unit price dispensers is nonretroactive, a user requirement, added to the Handbook in 1989 and later amended, establishes successive dates after which:

- any dispenser (with limited exceptions) placed in use in a multi-tier pricing application must compute and display total sale prices for deliveries at all unit prices offered from that dispenser; and

- all dispensers, regardless of when installed, must be used only for sales for which they compute and display the sales price.

UR.3.3. Computing Device.

(a) Any computing device used in an application where a product or grade is offered for sale at more than one unit price (excluding fleet sales and other price contract sales), shall be used only for sales for which the device computes and displays the sales price for the selected transaction. (Added 1989) (Amended 1992)
(Became Retroactive 1999)

(b) A truck stop dispenser used exclusively for refueling trucks is exempt from the requirements in (a) if all purchases of fuel are accompanied by a printed receipt of the transaction containing the applicable price per gallon, the total gallons delivered, and the total price of the sale.
(Added 1993)

(c) Unless a truck stop dispenser used exclusively for refueling trucks complies with S.1.6.4.1. (Display of Unit Price), the price posted on the dispenser and the price at which the dispenser is set to compute shall be the highest price for any transaction which may be conducted.
(Added 1993)

In accordance with UR.3.3.(a), if a station is using dispensers in a multi-tier pricing application, all dispensers, whether new or old, must compute and display total sales prices for all unit prices for which product is sold through the dispenser.

It is important to keep in mind that these requirements apply to individual dispensers and that their specific applicability depends upon the way in which a dispenser is used. The fact that a product may be offered for sale at different prices at a station does not necessarily mean that *every* dispenser must display all unit prices, provide means for selecting all unit prices, or have computing capability for all unit prices.

Consider, for example, a station that offers self or full service and a discount for cash. As at most stations, dispensers are dedicated to either self or full service: some dispensers offer full service, others self service, but no dispenser offers both self and full service. In contrast, the customer can choose the method of payment (cash or credit) at any dispenser. So, any given product may be offered at four different unit prices at this station: full service/credit, full service/cash, self service/credit, self service/cash. However, a given dispenser will only offer two unit prices, one for credit, one for cash. Requirements for display of unit price, unit price selection, and computing capability apply only to individual dispensers. So, in this example, a full service dispenser would be required to display full service credit and cash purchase unit prices only, since self service is not offered from that dispenser. [UR.3.3.(c) and (d), like S.1.6.4.1., make special provisions for truck stop dispensers.]

Recorded Representations, Point of Sale Systems

Recorded representations in the form of printed receipts or delivery tickets are not required for retail motor-fuel devices. However, if they are provided, they must include specific information about the transaction. Receipts printed by cash registers that are interfaced with dispensers (as at a convenience store) may include sales information for other merchandise. However, when the receipt includes motor fuel, it must show the volume, unit price, total computed price, and the product identity.

> ***S.1.6.7. Recorded Representations.*** *- Except for fleet sales and other price contract sales, a printed receipt providing the following information shall be available through a built-in or separate recording element for all transactions conducted with point-of-sale systems or devices activated by debit cards, credit cards, and/or cash:*
>
> *(a) the total volume of the delivery,*
>
> *(b) the unit price,*
>
> *(c) the total computed price, and*
>
> *(d) the product identity by name, symbol, abbreviation, or code number.*
> *[Nonretroactive as of January 1, 1986.]*
> (Added 1985) (Amended 1997)

As will be explained in the next chapter, a ticket should be printed after each test draft (if the system is equipped with a printer or printing cash register). The inspector should check these tickets to make sure that all required items are included. Additional requirements for printed tickets issued by the device are covered under Liquid-Measuring Devices Code paragraph UR.3.4., which is discussed in Chapter 6.

MEASURING ELEMENTS

Air Eliminator Vent

To assure that the customer receives the full measure of product that he or she is paying for, all liquid-measuring devices are required to be equipped with means of removing air and/or vapor from the liquid flow before it enters the meter.

> **S.2.1. Vapor Elimination.**
>
> (a) A liquid-measuring device shall be equipped with a vapor or air eliminator or other automatic means to prevent the passage of vapor and air through the meter.
>
> (b) Vent lines from the air or vapor eliminator shall be made of metal tubing or other rigid material. (Amended 1975)

As you learned in Chapter 3, the air eliminator in a submerged-pump system is located in the discharge head, and gases are vented directly into the storage tank. Because these units are relatively inaccessible and less subject to damage or tampering, they need not be inspected in the course of a routine field examination.

You will also recall from the discussion in Chapter 3 that suction-pump dispensers are designed with a special chamber where air and vapor are continuously separated from the liquid fuel and vented to the atmosphere by means of a tube that passes from the chamber to the outside of the cabinet. If the vent tube becomes blocked or damaged in some way that obstructs the escape of air and vapor, these gases no longer separate from the fuel, and may pass through the meter, causing incorrect measurement. A break or puncture in the tube can also result in buildup of vapor within the cabinet, thereby creating a hazard of fire and/or explosion.

The vent tube serving a suction-pump dispenser is therefore required to be made of metal or some other rigid material to reduce the risk of kinking, crimping, cracking, or accidental rupture.

When performing the inspection for this item and the next, the dispenser cabinet will have to be open. This will generally require a key, which should be provided by the station attendant or proprietor.

Inspect the vent tube carefully to determine that it is made of appropriate material and that there are no signs of damage that might cause obstruction or breaks in the tube that could allow vapor buildup in the cabinet.

Security Seal on Adjusting Mechanism

No security seal can prevent tampering with the meter adjustment mechanism. But if installed properly, the seal will provide clear evidence of tampering if it has occurred. In order to accomplish this, the device must be designed in such a way that a seal can be applied and, once in place, no adjustment can be made without destroying the seal.

S.2.2. Provision for Sealing. - Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or physically applying security seals in such a manner that no adjustment may be made of:

(a) any measurement element, or

(b) any adjustable element for controlling delivery rate when such rate tends to affect the accuracy of deliveries.

When applicable, the adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

(c) Audit trails shall use the format set forth in Table S.2.2. [Nonretroactive and enforceable as of January 1, 1995.] (Amended 1991, 1993, and 1995)

Table S.2.2. Categories of Device and Methods of Sealing	
Categories of Device	*Method of Sealing*
Category 1: No remote configuration capability	*Seal by physical seal or two event counters: one for calibration parameters and one for configuration parameters.*
Category 2: Remote configuration capability, but access is controlled by physical hardware. *Device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode.* *[Category 2 applies only to devices manufactured prior to January 1, 2005. Devices with remote configuration capability manufactured after that date must meet the sealing requirements outlined in Category 3. Devices without remote configuration capability manufactured after that date will be required to meet the minimum criteria outlined in Category 1.]*	*[The hardware enabling access for remote communication must be on-site. The hardware must be sealed using a physical seal or an event counter for calibration parameters and an event counter for configuration parameters. The event counters may be located either at the individual measuring device or at the system controller; however, an adequate number of counters must be provided to monitor the calibration and configuration parameters of the individual devices at a location. If the counters are located in the system controller rather than at the individual device, means must be provided to generate a hard copy of the information through an on-site device.]** *[*Nonretroactive as of January 1, 1996]*
Category 3: Remote configuration capability access may be unlimited or controlled through a software switch (e.g., password). *The device shall clearly indicate that it is in the remote configuration mode and record such message if capable of printing in this mode or shall not operate while in this mode. [Nonretroactive as of January 1, 2001]* *Nonretroactive as of January 1, 2005, all devices with remote configuration capability must comply with the sealing requirements of Category 3.*	*An event logger is required in the device; it must include an event counter (000 to 999), the parameter ID, the date and time of the change, and the new value of the parameter. A printed copy of the information must be available through the device or through another on-site device. The event logger shall have a capacity to retain records equal to ten times the number of sealable parameters in the device, but not more than 1000 records are required. (Note: Does not require 1000 changes to be stored for each parameter.)*

[Nonretroactive as of January 1, 1995.] (Table Added 1993) (Amended 1995, 1998, and 1999)

As explained previously (under **Provision for Sealing**), paragraph G-UR.4.5. of the General Code makes it the responsibility of the owner or operator of the device to make sure that adjustable elements are properly sealed at all times.

Inspect the existing seal carefully to determine that it is installed properly and that it shows no evidence of tampering. If it is properly installed and secure, there is no need to remove it at this stage. The procedure for installing the security seal will be presented in Chapter 7.

Audit trails are a relatively new method of sealing. While Handbook 44 has allowed their use since 1990, Table S.2.2. was not added until 1993. At the present time most retail motor-fuel dispensers fall under the definition of a Category 1 or Category 2 device, as explained in table S.2.2. Unlike a physical seal, the audit trail method of sealing is not visually apparent when observing the device or a device component like the measuring element. Blend settings on a variable ratio or an adjustable ratio blender are the most common elements of a retail motor-fuel dispenser that are secured with an audit trail method of sealing. Here the inspector, if unfamiliar with checking audit trail details, must rely on the NTEP Certificate of Conformance for the device, or contact the manufacturer or service company for instructions for accessing audit trail information. Gaining access to the audit trail information is relatively simple, and manufacturers have protected you and the system with safeguards to prevent your actions from altering system settings. When inspecting a device equipped with an audit trail, the inspector should record the values indicated for reference during future inspections or in response to consumer complaints. If the event counters show a significant number of changes since the last inspection, the inspector should attempt to determine whether or not the changes were for legitimate reasons. The inspector should also contact his or her supervisor for guidance on whether or not additional investigation might be warranted.

Changes made to Table S.2.2. allow a wider definition of Category 2 devices. However, for devices manufactured **after** January 1, 2005, there will only be provisions for Category 1 and Category 3 devices.

DISCHARGE HOSE

In order to assure that all product that passes through the meter is delivered to the customer who is being charged for it, there must be no means for diverting fuel to any other destination. Any bypass line from the meter outlet back to supply lines or the system storage tank is obviously prohibited. Multiple discharge outlets could be used to facilitate fraud, so they are permitted only to provide for special circumstances, and then only with specified safeguards.

The gasoline pumps installed at most filling stations are designed to service vehicles which have only one fuel tank and which can be parked in relatively close proximity to the dispenser for fueling. Units equipped with multiple discharge outlets are generally not suitable to such service.

Many large trucks, however, have two fuel tanks. To service them more efficiently, some truck stops have installed “satellite” dispenser systems. Under this scenario, the truck is parked between two service islands. On one island is the main dispenser. The dispenser is equipped with a meter and computer, and it is just like any other dispenser except that two discharge lines lead from the meter outlet. One line serves the hose connected to the main dispenser; the other line runs under the driveway separating the two islands and is connected to the satellite dispenser on the second island. The satellite consists simply of a chassis and a discharge hose. It has no measuring or indicating components of its own because all product delivered through it has already passed through the meter at the main dispenser.

Paragraph S.3.3 of the LMD Code allows such installations when they are used for fueling trucks and when adequate means are provided to prevent simultaneous delivery to more than one vehicle. Examples of such means of preventing diversion of metered product include physical barriers to driveways adjacent to the service islands and visible flow indicators that can be monitored from the customer position. Explanatory signs must also be provided. The operation of a dispenser/satellite system is depicted in Figure 5-7.

These models are for applications requiring higher flow rates. They can operate as a master when teamed with a satellite or alone. A master meters and controls the satellite. This configuration can deliver up to 60 gpm.*

1 Fuel passes through a shear valve then enters dispenser.

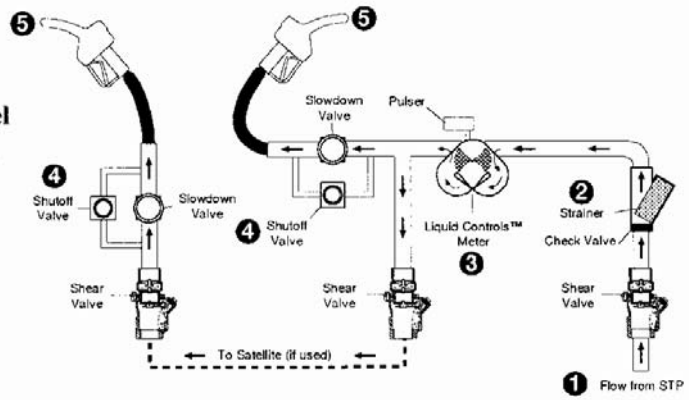
2 Fuel flows through a check valve and strainer.

3 Fuel flows through a Liquid Controls™ meter.

4 Metered fuel passes through a single-stage shutoff valve and slowdown valve in parallel and through piping to the satellite.

5 Fuel discharges through the nozzle.

High speed diesel dispenser with a satellite



* *Actual flow rate depends on installation and accessories used. Some local codes do not allow simultaneous operation of master and satellite.*

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Master

The valve in a master unit is located after the meter; this allows for a higher flow rate in the master and satellite units when operating simultaneously.

Note: Refer to NFPA 30A, local and state regulations to determine what type of operation is allowed in your area.

Types of Operation

- Simultaneous Operation - Allows customer to fuel saddle-tank vehicle with master and satellite unit at same time.
  Note: Some regulatory agencies require a physical barrier.
- Independent Operation - Allows customer to fuel a saddle-tank vehicle one side at a time.

Satellite

The satellite unit operates in conjunction with a master unit which meters the fuel.

FIGURE 5-7. OPERATION OF A DIESEL DISPENSER/SATELLITE SYSTEM

S.3. Discharge Lines and Valves.

S.3.1. Diversion of Measured Liquid. - No means shall be provided by which any measured liquid can be diverted from the measuring chamber of the meter or its discharge line. Two or more delivery outlets may be installed only if automatic means are provided to ensure that:

(a) liquid can flow from only one outlet at a time, and

(b) the direction of flow for which the mechanism may be set at any time is clearly and conspicuously indicated.

A manually controlled outlet that may be opened for purging or draining the measuring system or for recirculating product in suspension shall be permitted only when the system is measuring food products or agri-chemicals. Effective means shall be provided to prevent passage of liquid through any such outlet during normal operation of the measuring system and to inhibit meter indications (or advancement of indications) and recorded representations while the outlet is in operation. (Amended 1991, 1995, and 1996)

You may also encounter situations where a satellite system has been installed to facilitate access to a dispenser from different vehicle positions. However, delivery is permitted from only one discharge hose at any time, and means must be provided to prevent simultaneous delivery and to indicate which outlet is operative at any given time.

S.3.2. Exceptions. - The provisions of S.3.1. Diversion Prohibited shall not apply to truck refueling devices when diversion of flow to other than the receiving vehicle cannot readily be accomplished and is readily apparent. Allowable deterrents include, but are not limited to, physical barriers to adjacent driveways, visible valves, or lighting systems that indicate which outlets are in operation, and explanatory signs. (Amended 1982, 1990,1991, and 2002)

All retail motor-fuel devices are pump-discharge devices with flexible discharge hoses, and so must be of the wet-hose type. That is, they are designed so that the discharge hose is always completely filled with liquid fuel. As described earlier in this course, this ensures that the amount of fuel that passes through the meter during any single delivery will actually be delivered to the vehicle.

S.3.3. Pump-Discharge Unit. - A pump-discharge unit equipped with a flexible discharge hose shall be of the wet-hose type.

A discharge hose that is not properly reinforced will tend to "give" and may thereby contribute to the condition known as "computer jump." Computer jump occurs when fuel on the discharge side of the meter is not pressurized as quickly as fuel on the pump side, causing the computer to move slightly and register a small amount, even though no fuel has actually been delivered. This most often occurs as the result of expansion and contraction resulting from fluctuations in temperature, exposure to the sun or wind, and periods of rest (e.g., while the station is closed overnight). The LMD Code requires that discharge hoses be sufficiently rigid to minimize these effects.

S.3.5. Discharge Hose. - A discharge hose shall be reinforced so that the performance of the device is not affected by the expansion or contraction of the hose.

Another important reason for reinforcing the discharge hose is to minimize the risk of rupture if it is run over by a vehicle moving into or away from the service island. An adequately reinforced hose is also less likely to kink when extended to reach the vehicle fill opening.

UR.1.1. Discharge Hose.

UR.1.1.1. Length. - The length of the discharge hose on a retail motor-fuel device:

(a) shall be measured from its housing or outlet of the discharge line to the inlet of the discharge nozzle;

(b) shall be measured with the hose fully extended if it is coiled or otherwise retained or connected inside a housing; and

(c) shall not exceed 18 feet unless it can be demonstrated that a longer hose is essential to permit deliveries to be made to receiving vehicles or vessels.

An unnecessarily remote location of a device shall not be accepted as justification for an abnormally long hose.
(Amended 1972 and 1987)

UR.1.1.2. Marinas and Airports.

UR.1.1.2.1. Length. - The length of the discharge hose shall be as short as practicable, and shall not exceed 50 feet unless it can be demonstrated that a longer hose is essential.

UR.1.1.2.2. Protection. - Discharge hoses exceeding 26 feet in length shall be adequately protected from weather and other environmental factors when not in use.
(Made retroactive 1974 and amended 1984)

To reduce the risk of damage to the hose and minimize the effects of computer jump, the discharge hose should be no longer than necessary to reach vehicle fill openings.

Paragraph UR.1.1 generally requires that a discharge hose be no longer than 18 feet. But exceptions to this requirement are allowed in cases where additional length is required to reach the receiving vehicle. A general exception, in the form of a maximum length of 50 feet, is also provided for dispensers installed at airports and boat docks or marinas.

Check the length of the discharge hose. If a reeling device or retractor is employed, the hose should be measured when fully extended. Inspect the hose carefully for any signs of excessive wear, damage, or deterioration from exposure to the elements.

Since gas pumps are wet-hose devices, the discharge valve must be at the end of the discharge line, and there must be no other means for non-automatic regulation of flow between the meter and the discharge valve.

S.3.6. Discharge Valve. - A discharge valve may be installed in the discharge line only if the device is of the wet-hose type. Any other shutoff valve on the discharge side of the meter shall be of the automatic or semiautomatic predetermined-stop type or shall be operable only:

(a) by means of a tool (but not a pin) entirely separate from the device, or

(b) by mutilation of a security seal with which the valve is sealed open.

S.3.7. Antidrain Means. - In a wet-hose pressure-type device, means shall be incorporated to prevent the drainage of the discharge hose.

For example, a manual shutoff valve at the dispenser end of the discharge hose would be prohibited by S.3.6. and S.3.7. unless there is an anti drain means associated with the valve. The automatic overfill shutoff that is incorporated on many discharge nozzles is permitted, since it is automatic in operation, and because it cannot affect the accuracy of measurement. Safety regulations, specified in National Fire Protection Association (NFPA) 30A, prohibit the use of a manual (non-automatic) nozzle for motor fuel dispensers.

Additional Inspection Procedures

Your jurisdiction may require additional inspection procedures as part of a routine examination. For example, some jurisdictions require inspection of storage tanks for water contamination.

Your instructor will describe additional inspection procedures, along with applicable specifications and requirements.

SUMMARY

The Inspection is one of four components of an official field examination. Its general objective is to determine whether changes have occurred since the device was installed that might affect its conformance with specifications and requirements relating to design, installation, maintenance, and use. Examination Procedure Outlines (EPOs) organize the requirements set forth in Handbook 44 in a systematic way, suited to efficient field procedures. EPO 21 for single-, dual-, and multi-product retail motor-fuel dispensers and EPO 22 for blended-product retail motor-fuel devices classify requirements in five areas:

- General considerations;
- Marking requirements;
- Indicating and recording elements;
- Discharge hose; and
- Measuring elements.

CHAPTER 6

THE TEST

CHAPTER OBJECTIVES

Upon completion of this chapter, you should be able to:

1. Make Pretest Determinations relating to tolerances and product storage identification.

2. Understand and use the Test portion of the appropriate Examination Procedure Outline, including Test Notes.

3. Identify specific procedures for testing single-product retail motor-fuel devices.

4. Identify specific procedures for testing blended-product retail motor-fuel devices.

INTRODUCTION

This chapter presents the procedures for testing retail motor-fuel dispensers to determine compliance with performance requirements. These performance requirements relate to the ability of the device to measure and deliver motor fuel and to indicate, compute, and record these deliveries accurately and consistently under normal operating conditions. Performance is tested against specified tolerances.

As with the section on the Inspection, we will follow the EPO's, quoting and commenting on relevant code references and describing the step-by-step procedure.

PRETEST DETERMINATIONS

Before the Test is conducted, certain Pretest Determinations must be made to ensure that proper tolerances are applied and that other test factors are correct.

Figure 6-1 shows a portion of the Pretest Determinations section of EPO 21 and 22. Pretest Determinations for single- (includes dual and multi-product dispensers) and blended-product dispensers are identical.

Excerpts from EPO 21 and 22

Pretest Determinations:

1. Tolerances.
   Applicable requirements.....G-T., T.1.
   Basic values.....T.2.

2. Product storage identification.....UR.2.5.

Test Notes:

Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from splashed product

Do not leave an activated dispenser unattended !

1. If test measure is dry, add 16.4 milliliter (one cubic inch) to gauge reading to allow for amount of liquid required to "wet" measure.

2. Hand held test measures require a 30-second (± 5 second) pour followed by a 10-second drain, with the measure held at a 10 to 15 degree angle from vertical. (see NIST HB 105-3, Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards, 1997, section 7).

Ground test measure properly and only use a metal funnel when returning product to storage

Note: For the remainder of the EPO see the complete copy in the back of your notebook

Figure 6-1. EPO, Pretest Determinations

Tolerances

It is recognized that errorless value or performance of weighing and measuring devices is virtually unattainable. Tolerances are established, therefore, to fix the acceptable range of inaccuracy for devices in commercial use. Tolerances are intended to permit errors that are small enough that they can not cause serious economic injury to either buyer or seller. At the same time, tolerances can not be so stringent as to make the costs of manufacturing and maintaining equipment unreasonably burdensome: these costs would simply be passed on to the consumer in any case. Tolerances established by code or regulation are considered by manufacturers as minimum requirements. Individual manufacturers and industries can, and often do, establish performance tolerances that are more stringent.

For motor-fuel dispensers two sets of tolerances are established:

- acceptance tolerances are applied to new equipment when it is first put into service, when it is returned to service after reconditioning or replacement of major components, when adjustments or repairs have been made as the result of official rejection in a previous examination, or when it is undergoing type evaluation; and

- maintenance tolerances are applied to equipment that has been in service for more than 30 days.

Acceptance tolerances for retail motor-fuel devices are specified as 1/2 the value of the maintenance tolerances (see T.2., below). Thus maintenance tolerances provide a somewhat less stringent compliance standard. This allows a limited degree of deterioration in performance and generally assures a reasonable period of use before the device must be reconditioned.

G-T.1. Acceptance Tolerances. - Acceptance tolerances shall apply to:

(a) equipment to be put into commercial use for the first time;

(b) equipment that has been placed in commercial service within the preceding 30 days and is being officially tested for the first time;

(c) equipment that has been returned to commercial service following official rejection for failure to conform to performance requirements and is being officially tested for the first time within 30 days after corrective service;

(d) equipment that is being officially tested for the first time within 30 days after major reconditioning or overhaul; and

(e) equipment undergoing type evaluation.
(Amended 1989)

G-T.2. Maintenance Tolerances. - Maintenance tolerances shall apply to equipment in actual use, except as provided in G-T.1.

Both acceptance and maintenance tolerances apply to errors of underregistration and overregistration.

- Underregistration involves the indication of a smaller volume of product than has actually been delivered, and favors the buyer.

- Overregistration involves the indication of a greater volume of product than has actually been delivered, and favors the seller.

G-T.3. Application. - Tolerances "in excess" and tolerances "in deficiency" shall apply to errors in excess and to errors in deficiency, respectively. Tolerances "on overregistration" and tolerances "on underregistration" shall apply to errors in the direction of overregistration and of underregistration, respectively. (See Appendix D, Definitions.)

G-T.4. For Intermediate Values. - For a capacity, indication, load, value, etc., intermediate between two capacities, indications, loads, values, etc., listed in a table of tolerances, the tolerances prescribed for the lower capacity, indication, load, value, etc., shall be applied.

T.1. Application to Underregistration and to Overregistration. - The tolerances hereinafter prescribed shall be applied to errors of underregistration and errors of overregistration, whether or not a device is equipped with an automatic temperature compensator.

Reference is made to "normal" and "special" tests. This distinction will be explained below. Note, however, that the same tolerances apply to both normal and special tests. Maintenance and acceptance tolerances for retail motor-fuel devices are based upon a percentage of the quantity of the test draft.

Referring to paragraph T.2 and Table T.2., if a 5-gallon draft is to be used, the maintenance tolerance will be 6 cubic inches.

The acceptance value for this draft will be 3 cubic inches. For a maintenance test, if the difference between the indicated volume and the delivered volume was greater than 6 cubic inches (either plus or minus), the dispenser would not be in compliance. The test procedure used to make this determination will be discussed later.

Repeatability tests are tests made at approximately the same flow rate. For instance two or more tests made at the high nozzle latch position, or two or more tests made at the low nozzle latch position could be considered repeatable tests. Care should be taken to assure that the flow rate is approximately the same for each repeatability test run; other dispensers in use at the same time, for instance, may have an effect on the flow rate of the particular dispenser being tested. The range of tests (spread) shall not exceed 40 percent of the absolute value of the maintenance tolerance, reference paragraph T.3.. In the above example the maintenance tolerance is 6 cubic inches. The repeatability tolerance for additional tests taken at approximately the same flow rate is 2 cubic inches (0.40 x 6 cu in = 2.4 use 2 cu in).

Applicable tolerances should be determined and recorded before the test procedure begins. To do this, you need to know the number of indicated gallons that will be used in the test procedure. This will normally be 5 if the device has a maximum discharge rate of less than 20 gal/min (less than 80 L/min for metric devices), as is the case for most retail dispensers. For dispensers with higher maximum discharge rates, test drafts are required to equal the amount of fuel discharged in one minute at the highest rate (see paragraph N.3.4., which appears in the Test section of this Chapter).

T.2. Tolerance Values. Maintenance, Acceptance, and special Test Tolerances shall be as shown in Table T.2.

Table T.2. Accuracy Classes for Liquid Measuring Devices Covered in NIST Handbook 44 Section 3.30

Accuracy Class	Application	Acceptance Tolerance	Maintenance Tolerance	Special Test Tolerance
0.3	Petroleum products including large capacity motor fuel devices (flow rates over 115 L/min (30 gpm))**, heated products at or greater than 50 °C asphalt at or below temperatures 50 °C, all other liquids not shown where the typical delivery is over 200 L (50 gal)	0.2 %	0.3 %	0.5 %
0.3A	Asphalt at temperatures greater than 50 °C	0.3 %	0.3 %	0.5 %
0.5*	Petroleum products delivered from small capacity (at 4 L/min (1 gpm) through 115 L/min (30 gpm))** motor-fuel devices, agri-chemical liquids, and all other applications not shown.	0.3 %	0.5 %	0.5%
1.1	Petroleum products and other normal liquids from devices with flow rates** less than 1 gpm and devices designed to deliver less than one gallon.	0.75 %	1.0 %	1.25%

*The maintenance tolerances on normal and special tests for 5-gallon and 10-gallon test drafts are 6 cubic inches and 11 cubic inches, respectively. Acceptance tolerances on normal and special tests are 3 cubic inches and 5.5 cubic inches.

** Flow rate refers to designed or marked maximum flow rate.

T.3. Repeatability. - When multiple tests are conducted at approximately the same flow rate, the range of the test results for the flow rate shall not exceed 40 percent of the absolute value of the maintenance tolerance.

(Added 1992)

Product Storage Identification

As you know, except for blended products, each different product or grade of fuel sold must have its own storage tank(s). Mixture resulting from accidentally introducing a product or grade of fuel into the wrong storage tank can have serious consequences. First, the consumer will not be getting what he or she is paying for. Worse, however, many engines may be damaged by operating them with the wrong product.

To avoid accidental mixing of products in the storage tanks, fill pipes must be clearly marked to indicate to suppliers and all other persons who have access to them—including the inspector, who will be returning test drafts to the tanks—what product and grade of fuel they contain. A number of different methods of identification are in common use, including printed tags and color coding.

UR.2.5. Product Storage Identification.

(a) The fill connection for any petroleum product storage tank or vessel supplying motor-fuel devices shall be permanently, plainly, and visibly marked as to product contained.

(b) When the fill connection device is marked by means of a color code, the color code key shall be conspicuously displayed at the place of business.
(Added 1975 and amended 1976)

You should remove the protective cover from each fill pipe opening and inspect the markings to determine that the required information is complete and that it is clearly, legibly, and permanently marked. If a color-coding system is used, a legend must be provided.

TEST NOTES

When you have completed the Pretest Determinations you are ready to begin the Test of the dispensing system's performance. The EPO provides step-by-step instructions for each stage of the procedure. Several steps are performed repeatedly at various stages in the Test. In order to make the outline of the procedure simpler and easier to follow, these steps are described in a separate section of the EPO immediately preceding the Test section, and are referred to as Test Notes.

The Test Notes for single- and blended-product dispensers are identical except that one additional note concerning returning product to storage is included in the EPO for blended-product dispensers (see Figure 6-2).

Items 1 and 2 in the Test Notes have been described in detail in Chapter 4 of this course. You may want to review that discussion before continuing.

Item 3. Handbook 44 requires totalizers (paragraph S.5. - nonretroactive as of *January 1, 1995*), however most dispensers are equipped with totalizers, both for money values and volume. These elements indicate running totals for a period of time and for a number of deliveries, they may be mechanical, electro-mechanical or electronic. They provide the proprietor with information on sales that is useful for inventory management and for detecting fraud or pilfering by suppliers or employees. The above referenced paragraph requires that totalizers be nonresettable. In most cases totalizers, prior to this requirement were also nonresettable.

Totalizers are not considered to be primary indicating elements unless they are used as the basis for transactions between a buyer and a seller. Although they are often used exclusively for the convenience of the operator and not as the basis for sales, you have learned that there are exceptional situations (self-operated devices, consignment agreements with suppliers, etc.) in which totalizers are primary elements, and are subject to specifications and requirements for design, readability, etc. Totalizers that are primary indicating elements must also meet the performance requirements for comparability and variation between indicated price and the price computed mathematically.

Excerpts from EPO 22

Test Notes:

Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from splashed product

Do not leave an activated dispenser unattended !

1. If test measure is dry, add 16.4 mL (one cubic inch) to gauge reading to allow for amount of liquid required to "wet" measure.

2. Hand held test measures require a 30-second (± 5 second) pour followed by a 10-second drain, with the measure held at a 10 to 15 degree angle from vertical. (see NIST HB 105-3, Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards, 1997, section 7).

Ground test measure properly and only use a metal funnel when returning product to storage

3. To determine proper operation of totalizers, read and record the totalizer indications before and after all test drafts. S.5. (1/1/95)

4. After each test draft:
   - a. print ticket if device is so equipped.....G-S.5.6., S.1.6.7. (1/1/86), UR.3.4.
   - b. check price computations on all indicators .....S.1.6.5.(a) (1/1/91)
     (including consoles) and on recorded representations.
     - digital equipment .....G-S.5.5.
     - analog equipment.....S.1.6.5.(b), N.4.3.2.
   - c. check for agreement between indications .....G-S.5.2.2., S.1.6.6.(a), S.1.6.6.(b) (1/1/88)

5. Verify after a delivery is completed, the quantity and total price are displayed for at least 5 minutes or until the next transaction..... S.1.6.5.5. (1/1/94

FIGURE 6-2 TEST NOTES, EPO FOR BLENDED-PRODUCT DISPENSERS

Even if the totalizers are not primary elements in the system you are examining, readings should be recorded at the beginning and end of each test draft. There are two reasons for this procedure. The first is that you will have to account for all product dispensed in the course of the examination so that the operator can reconcile inventory figures (totalizers will show that product has been delivered, even though test drafts have subsequently been returned to storage tanks). The second reason is that totalizers are interlocked with other indicating elements, and thus provide a means of checking other indicated values.

Both money and volume totalizers should be read and the indicated values recorded before and after each test draft is drawn. The difference between ending and beginning readings should agree with primary indicating elements. If they do not agree, there is a malfunction in the indicating system, and further tests may be required to locate it.

Item 4

4.1 If the dispenser is connected to an automatic ticket printer, the printer is a primary recording element, and is generally subject to the same requirements for readability, Maximum Allowable Variation (MAV) between recorded price and mathematically computed price, and comparability with other primary elements as indicating elements (G-S.5.6.; see discussion of this paragraph in the last chapter, under **Indicating and Recording Elements, Readability**). These requirements are described under **b** and **c** in this section.

Receipts printed by cash registers that are interfaced with dispensers (as at a convenience store) may include sales information for other merchandise. However, when the receipt includes motor fuel, in accordance with Paragraph S.1.6.7. (explained in Chapter 5 under "Recorded Representations, Point of Sale Systems"), the receipt must show the volume, unit price, total computed price, and the product identity. An example of such a ticket is shown in Figure 6-3..

GAS TO GO
1234 Fifth Street
Your Town, State Zip

Trans. # 87654321 11/17/97 8:40 A

Product	Quantity (gal)	Price	Total
Prem. unl.	8.678	$1.299	$11.27
Other Merchandise (incl. Tax)			2.89
	Total Purchase		$14.16

FIGURE 6-3. PRINTED TICKET

A related requirement, UR.3.4., states that any printed ticket issued by the device must display the total price, unit price, and total volume, although these items may be written in a clear hand script. This provision would allow, for example, for a ticket issued by a totalizing device: the beginning and ending totalizer readings might be printed, with the operator computing the total price and volume and marking these by hand, along with the unit price, on the ticket. Paragraph UR.3.4. does not apply to bank card readers or other printing elements that are not interfaced with a retail motor-fuel dispenser, console, or other portion of the measuring system.

> **UR.3.4. Printed Ticket.** - The total price, the total volume of the delivery, and the price per gallon or liter shall be shown, either printed or in clear hand script, on any printed ticket issued by a device and containing any one of these values.
> (Amended 2001)

Because repeatability is a requirement of an accurate device, printed tickets should be checked after each test draft, even if the first recorded indications are correct. If discrepancies are found between the printer and other primary elements, additional tests may be required to isolate the malfunctioning element.

4.2 The unit price for most motor-fuel products includes fractional cents and the quantity delivered often includes a fraction of a gallon, but the computed price is always indicated in whole cents. The computing device, whether analog or digital, resolves fractions of cents into whole cents continuously. So the indicated or recorded price of a delivery will most often not be in exact agreement with the price computed mathematically.

For example, if the unit price is $1.299/gal and 8.678 gallons of the product are purchased, the price of the sale will be $11.27. However, computed mathematically, it will be slightly more:

Unit Price x Quantity = Sale Price
$1.299/gal x 8.678 gal = $11.273

The difference between the indicated or recorded money-value and the mathematically computed value is limited by Handbook 44 requirements. Note that the Maximum Allowable Variations (MAV's) specified are different for analog and digital devices.

In accordance with S.1.6.5.(b), the difference (whether plus or minus) between the indicated price and the price computed mathematically by an analog device must not exceed the MAV's specified in Table 1 of the LMD Code (reproduced in the last chapter, under **Money-Value Divisions**). The MAV's in Table 1 vary with the unit price and the type of examination (design tests are those performed as part of the NTEP evaluation; field tests are those conducted as part of a routine examination; see N.4.3.2.).

> **S.1.6.5. Money-Value Computations**
>
> * * *
>
> (b) The analog sales price indicated for any delivered quantity shall not differ from a mathematically computed price (quantity x unit price = total sales price) by an amount greater than the value in Table 1.
> (Amended 1984, 1989)
>
> **N.4.3.2. Field Tests**. - In the conduct of field tests to determine compliance with paragraph S.1.6.5., the maximum allowable variation in the indicated sales price shall be as shown in Table 1.

Note that S.1.6.5.(a) relates to computing capability, and was described in the last chapter, under **Multiple Unit Price Dispensers**).

In accordance with G-S.5.5., a digitally indicated, or recorded money value must agree with the mathematically computed value to the nearest one cent of money value. Formula: Quantity x Unit Price = Sales Price ± 1/2 cent.

G-S.5.5. Money Values, Mathematical Agreement. - Any recorded money value and any digital money-value indication on a computing-type weighing or measuring device used in retail trade shall be in mathematical agreement with its associated quantity representation or indication to the nearest one cent of money value. This does not apply to auxiliary digital indications intended for the operator's use only, when these indications are obtained from existing analog customer indications that meet this requirement. (Amended 1973)

Variation in excess of the MAV may indicate a mechanical malfunction in the computer, the effects of radio frequency or electromagnetic interference (RFI/EMI) if the device is electronic, or tampering with the computing device. The cause may become apparent as you continue the examination. If it does not, additional tests may be required.

Again, since repeatability is a requirement of accuracy, checks should be made of each primary indicating element after each draft. When testing multiple unit price dispensers, different unit prices should be selected on each test draft, to assure that the dispenser can meet the money-value computation requirement at all unit prices for which it can be set.

4.3 The readings taken from the primary indicating and recording elements after each draft should be recorded and compared. All indicated money values must agree exactly. If a system has both analog and digital elements, like values must agree to the nearest minimum graduation.

G-S.5.2.2. Digital Indication and Representation. - Digital elements shall be so designed that:

(a) All digital values of like value in a system agree with one another.

(b) A digital value coincides with its associated analog value to the nearest minimum graduation.

(c) A digital value "rounds off" to the nearest minimum unit that can be indicated or recorded.

(d) *A digital zero indication includes the display of a zero for all places that are displayed to the right of the decimal point and at least one place to the left. When no decimal values are displayed, a zero shall be displayed for each place of the displayed scale division. [Nonretroactive as of January 1, 1986.]*
(Amended 1973 and 1985)

S.1.6.6. Agreement Between Indications. - When a quantity value indicated or recorded by an auxiliary element is a derived or computed value based on data received from a retail motor fuel dispenser, the value may differ from the quantity value displayed on the dispenser, provided the following conditions are met:

(a) all total money values for an individual sale that are indicated or recorded by the system agree, and

(b) within each element, the values indicated or recorded meet the formula (quantity x unit price = total sales price) to the closest cent.

[Nonretroactive as of January 1, 1988.]
(Added 1985) (Amended 1987 and 1988)

Quantity values indicated or recorded on auxiliary elements may vary from those shown on the main primary indicator (as a result of using derived values) provided that all total money values indicated or recorded agree exactly and that the computed money-value displayed by the auxiliary element agrees with the mathematically computed value to the closest cent. For example, the money values on a remote indicator, such as a control console, must agree with those of the dispenser for any given delivery exactly; the indicated quantities may vary slightly, as long as the applicable requirements for agreement between indicated and mathematically computed values can also be met by the dispenser and the console separately.

THE TEST

The test comprises the same steps for single- and blended-product dispensers. However, several steps are repeated in the latter procedure. So we will look at the procedures given in EPO 21 for single-product dispensers first (see Figure 6-4), then compare them with the procedures in EPO 22 for blended-product dispensers.

1. Normal Test

The first procedure in the Test is referred to as the "Normal Test." The Normal Test of a retail motor-fuel dispensing system is intended to approximate as closely as possible the operating characteristics of the system during a normal delivery—that is, in the type of service for which the equipment is most often used. The performance of the entire system's ability to measure and indicate correctly under these conditions is tested.

When testing retail motor-fuel dispensers in the field you will always use the actual product dispensed, since substituting another liquid of the same general physical characteristics would necessitate draining the storage tanks, and this would constitute an unreasonable burden for the operator. (The requirement of N.1.1. is intended primarily for wholesale devices, especially loading-rack meters, which may be used to dispense liquids that cannot practicably and safely be tested, usually because of extreme toxicity, corrosiveness, or volatility.)

N.1.1. Type of Liquid. - The liquid used for testing a liquid-measuring device shall be the type the device is used to measure, or another liquid with the same general physical characteristics.

FIGURE 6-4 EPO FOR SINGLE-PRODUCT DISPENSERS, TEST SECTION

Excerpts from EPO 21 Test Section

Test:

Use proper lifting techniques when lifting test measure !

Be aware of and attempt to eliminate potential ignition sources in or near the inspection site

Be aware of vehicular and pedestrian traffic when moving between dispenser and storage tanks

1. Normal test--full flow, basic tolerance N.1.1., N.2., N.3.4., N.4.1., T.2., UR.2.2
   At the beginning of the first delivery,
   check for suppressed values. .....S.1.6.1.
   If first test result is at or near the tolerance
   limit, repeat this test. .....T.3., N.4.1.2.
   Petroleum Product Sampling[1]

2. Special test--slow flow, basic tolerance .....N.4.2., N.4.2.2., T.2.

3. RFI/EMI test (electronic equipment only) .....G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.
   Radio Frequency Interference (RFI)
   Electromagnetic Interference (EMI)

4. Check effectiveness of anti-drain means.....S.3.7.

5. Check effectiveness of zero-setback interlock. .....S.2.5.
   On equipment with remote pumping systems,
   activate one dispenser and check all others
   operated by the same pump to make certain
   they will not operate without activating the
   individual starting levers.

6. Power loss test .....S.1.6.2.1.(1/1/83), S.1.6.2.2. (1/1/83)
   Check with your supervisor before requiring shutdown of power to equipment under test.

7. Security means
   a. Check for / apply security seal .....G-UR.4.5.
   b. Record audit trail information.....S.2.2. (c) (1/1/95), Table S.2.2. (1/1/95)

Record on the official report, the number of gallons of product dispensed during testing.

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[1] When taking gasoline samples from single hose multi-product dispensers, the samples should be collected after an observed sale of the particular grade or product to be tested, or sufficient product should be purged from the hose to ensure the sample is representative of the grade or product being sampled. The National Conference on Weights and Measures policy on procedures for taking samples for octane verification is as follows: **"A minimum of a liter (0.3 gallon) of engine fuel shall be flushed from the dispensers before taking a sample for octane verification. This flush shall be returned to the storage tank containing the lowest octane."** (see NCWM Publication 21, Petroleum Products Sampling Procedures and Safety Manual, August 1997).

Reset the dispenser to zero (this may require "authorizing" the pump if it is controlled by a remote console) and check all indicators for zero reading.

A small amount of fuel may remain in the discharge nozzle (ahead of the antidrain valve) from the previous delivery. This is usually no more than a drop or two of liquid, and should under no circumstances be more than one cubic inch (it is simply clingage that was not drained when the nozzle was righted and hung on the dispenser). But even a small amount can affect test results. So you should drain this residual fuel into some suitable metal container other than the test measure before beginning the test.

Remove the nozzle from the boot and switch the dispenser on. When switched on, the dispenser's indicating elements should automatically reset to zero, with no values visible during the resetting process (S.1.3., discussed in the last chapter, under **Indicating and Recording Elements, Advancement and Return to Zero**). Before the discharge nozzle is operated, quantity and total sale price indicators should read zero exactly. However, you may observe what is known as "computer jump", that is, the indicators jumping ahead and showing a slight amount when the dispenser is pressurized, even though no fuel has actually been delivered. This condition is not abnormal when the dispenser has been out of use for a matter of hours. So if computer jump is observed, shut off the dispenser, re-zero the computer, and try again. If the computer jumps again on the second try, the device is not operating properly. You should inform the operator of this condition, even if the dispenser performs within tolerances, since it indicates a need for prompt attention to prevent the cause from affecting accuracy.

Computer jump can be attributed to one of several causes (see Figure 6-5):

- a deteriorated or substandard discharge hose that "gives" when the pump is pressurized, requiring a small amount of fuel to pass through the dispenser control valve and the meter before pressure is equalized;
- malfunctioning check or relief valves, allowing pressure to bleed back to the pump side;
- a malfunctioning antidrain means; or
- the effects of temperature change on the volume of fuel in the system, especially in the discharge hose

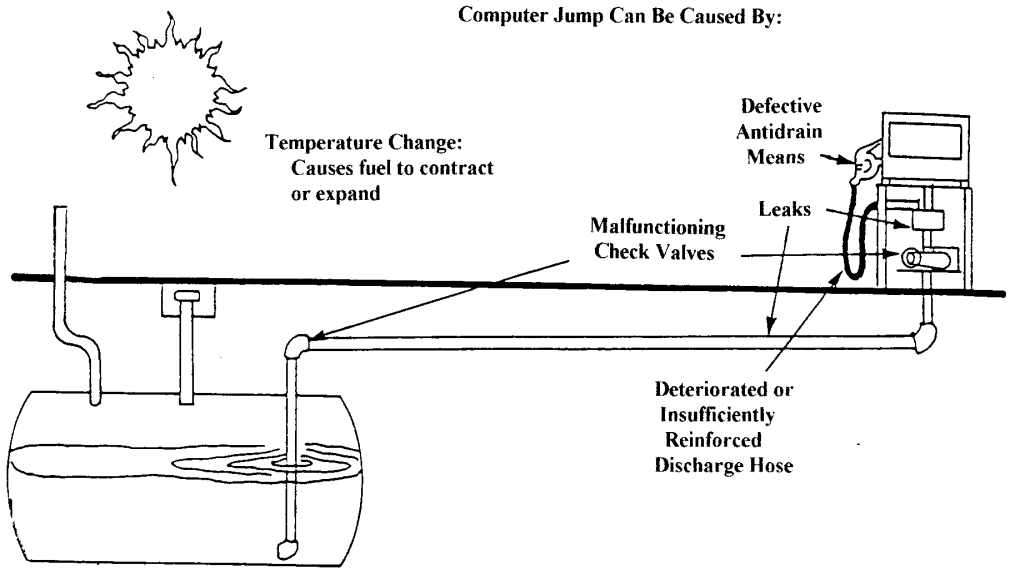

FIGURE 6-5. COMPUTER JUMP

(A special “elapsed-time test”, was formerly included in the EPO's to determine the amount of leakage error for a dispenser that showed computer jump in two consecutive trials. This test is no longer required for routine field examinations. However, your jurisdiction may require an elapsed-time test under certain test conditions. Your instructor will explain your jurisdiction's policy regarding elapsed-time tests and explain any required procedures to you.)

In fact, a very small amount of computer jump occurs every time the pump is pressurized, and is unavoidable. This small amount will not be detectable on most analog devices, which indicate amounts no smaller than hundredths of gallons. But many digital devices indicate thousandths of gallons. To avoid confusion and misunderstanding, such devices may suppress the first 0.009 gal (or 0.03 liters) and the associated price indicated (S.1.6.1., discussed in the last chapter under **Indicating and Recording Elements, Indication of Delivery**). These indications are generally simply blanked out, the first visible indications occurring at 0.010 gal. When testing digital equipment indicating in thousandths of a gallon, notice the first indicated amount to determine that it is not more than 0.010 gal (or 0.04 liters).

The normal test should be conducted in a manner that approaches, as far as possible, normal operating conditions. Since the greater part of most actual deliveries are made at the maximum discharge rate of the dispenser, you should do the same when dispensing drafts for this test, holding the discharge lever wide open until it is necessary to reduce flow to stop at the correct indication, or to prevent spillage from foaming fuel.

N.4.1. Normal Tests. - The “normal” test of a device shall be made at the maximum discharge flow rate developed under the conditions of installation. Any additional tests conducted at flow rates down to and including one-half of the sum of the maximum discharge flow rate and the rated minimum discharge flow rate shall be considered normal tests.
(Amended 1991)

For most dispensers installed to service primarily automobiles, a 5-gallon draft is sufficient for this test. Pumps intended for fueling large trucks generally are designed with higher flow rates, since truck fill pipes are larger and can generally accept high flow rates without backing up fuel and causing spillage. If the dispenser you are testing has a maximum flow rate of 20 gal/min (80 L/min) or greater, drafts of up to 50 gal may be required. In such situations, you will need a special prover, usually truck-mounted, to conduct the Test.

N.3.4. Other Retail Devices. - On devices with a designed maximum discharge rate of:

(a) less than 20 gallons (80 L) per minute, tests shall include drafts of one or more amounts, including a draft of at least 5 gallons.

(b) 20 gallons (80 L) per minute or greater, tests shall include drafts of one or more amounts, including a draft of at least the amount delivered by the device in one minute at the maximum flow rate of the installation.
(Amended 1984)

Test the discharge nozzle’s automatic shut-off valve, by touching the tip of the nozzle to the surface of the fuel toward the end of the draft. The nozzle should respond immediately, shutting off the flow.

Continue filling until the volume indicated on the dispenser equals the nominal capacity of the test measure (5 gal, etc.). The correct techniques for setting up and reading the test measure were described in Chapter 4. A reading should be taken as soon as possible after the draft is taken in order to prevent the effects of temperature change or evaporation from influencing Test results. Record errors, both plus and minus, carefully on your report form.

> **N.2. Volume Change.** - Care shall be taken to minimize changes in volume of the test liquid due to temperature changes and evaporation losses.

If the error is close to the applicable tolerance (as identified in the Pretest Determinations described earlier in this chapter), a second draft should be taken to confirm the results. Readings for this second draft should also be recorded.

Remember to observe all primary indicating and recording elements following each draft to determine agreement between indicated price and the mathematically computed price. Record any variations that exceed the MAV. This will require either arithmetic, a hand-held calculator, or the use of price computation tables. Also check all auxiliary indicating and recording elements for comparability and record any discrepancies.

2. Special Test (slow flow)

Special Tests are used to test the performance of the device under conditions that are not usual, but which may occur. They thus confirm (or fail to confirm) the results of "normal tests" for the range of operating characteristics of the dispenser. In the case of retail motor-fuel dispensers, the Special Test required is a slow-flow test. Your first step will be to determine the appropriate flow rate for the test, the least of the following:

- 5 gallons (19 L) per minute,
- the minimum discharge rate marked on the dispenser, or
- the minimum rate deliverable by an automatic nozzle set at its lowest setting.

> **N.4.2. Special Tests.** - "Special" tests, to develop the operating characteristics of a liquid-measuring device and any special elements and accessories attached to or associated with the device, shall be made as circumstances require. Any test except as set forth in N.4.1. shall be considered a special test.

N.4.2.2. Retail Motor-Fuel Devices. –

(a) Devices with a flow-rate capacity less than 100 L (25 gal) per minute shall have a "special" test performed at the slower of the following rates:

(1) 19 L (5 gal) per minute, or

(2) the minimum discharge rate marked on the device, or

(3) the minimum discharge rate at which the device will deliver when equipped with an automatic discharge nozzle set at its slowest setting.

(b) Devices marked with a flow-rate capacity 100 L (25 gal) or more per minute, shall have a "special" test performed at the slowest of the following rates:

(1) the minimum discharge rate marked on the device, or

(2) the minimum discharge rate at which the device will deliver when equipped with an automatic discharge nozzle set at its slowest setting.
(Added 1984)

The only way to assure yourself that you are delivering at the required rate is to time the draft. If you must regulate the flow rate manually, try to maintain as steady a rate as possible while remaining within the time limit. If the appropriate flow rate is anything other than 5 gal/min, you can determine the time required to deliver 5 gal at that rate by dividing 5 gal by the number of gallons/minute. For example, if the minimum discharge rate marked on the dispenser is 2.5 gal/min, a delivery of 5 gal should be made at such a rate as to be completed in 2 minutes:

$$\frac{5 \text{ gal}}{2.5 \text{ gal/min}} = 2 \text{ min}$$

(Convert fractional minutes to seconds by multiplying by 60. For example, 5.25 minutes is equal to 5 minutes and 15 seconds: .25 minute x 60 = 15 seconds.)

In all other ways, the procedure for this special test is identical to that for the normal test, except that it need not be repeated.

3. RFI/EMI Test

All weighing and measuring devices that have electronic components are subject to the effects of radio frequency and electromagnetic interference (RFI/EMI). These two types of interference have different sources, but are basically the same in their nature and their effects.

The passage of electric current through a conductor creates a magnetic field around the conductor. If the direction, amplitude, or intensity of the current changes, the magnetic field surrounding the conductor changes in response. This changing magnetic field is then capable of inducing a current in another conductor located within the field (see Figure 6-6). The same effect can be achieved by changing the position of the conductor relative to a stationary magnetic field (this is the basic principle employed in electric power generation).

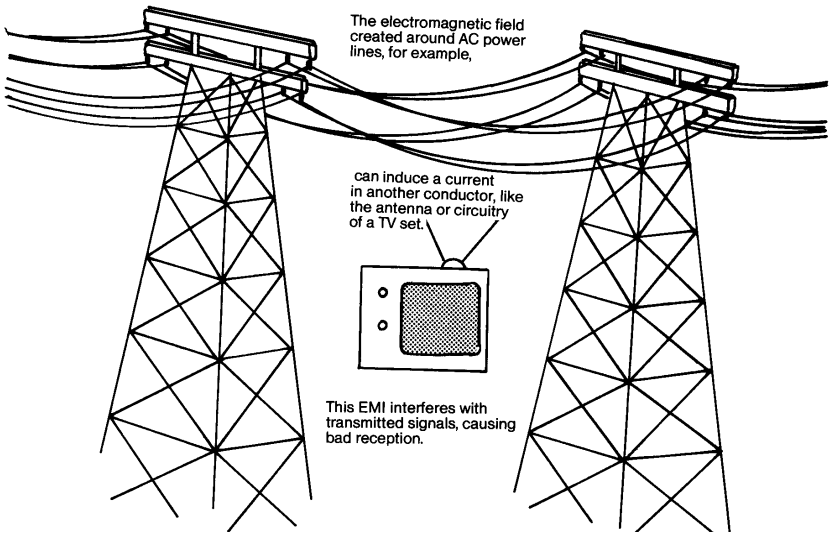

FIGURE 6-6. ELECTROMAGNETIC INTERFERENCE (EMI)

The circuitry of electronic devices consists of conductors that carry electrical signals. For example, you will recall from our discussion in Chapter 3, that in electronic fuel dispensers, discrete signals generated by the transducer (pulser) driven by the revolving meter shaft are transmitted through wiring to the CPU, where they are interpreted. If this wiring, or the circuitry of the transducer or the CPU, were to be brought into contact with a changing electromagnetic field, extraneous current could be produced. This extraneous current could either interfere with the pulses generated by the transducer, rendering them unrecognizable as signals, or under certain conditions it could produce additional pulses that might be interpreted as signals. In either case, the accuracy of the measuring device would obviously be impaired.

Under normal operating conditions, fuel dispensers are exposed to electromagnetic fields produced from a variety of sources. Among these are:

- radio-frequency transmitters from nearby broadcast facilities and mobile transmitters, like CB and commercial band two-way radios and mobile phones (RFI).
- generators, including those driven by vehicle engines to provide a continuous power supply (EMI).
- electrical discharge ignition (spark plugs) (EMI).
- power supply lines (EMI).
- appliances that have electric motors, like air conditioners and refrigeration systems, compressors, etc. (EMI).
- fluorescent lighting (EMI).

The electronic components of retail motor-fuel dispensers are designed in such a way as to be protected from interference from RFI and EMI under normal operating conditions. However, if these protections are defective or improperly installed, or if the equipment is located in a place where it is exposed to extraordinary amounts of

RFI or EMI (for example, next to the transmitting facility of a commercial radio or TV station) interference may occur.

The purpose of a testing procedure is not to determine the presence of RFI/EMI in the environment of the dispenser, but to determine whether the device is adequately protected from its effects, as required. Several sections in the General Code include requirements that relate to RFI/EMI (G-UR.1.2., G-UR.3.2., G-UR.4.2., and G-N.2.; these paragraphs are quoted together on the next page of text).

G-UR.1.2. Environment. - Equipment shall be suitable for the environment in which it is used including but not limited to the effects of wind, weather, and radio frequency interference (RFI).
(Added 1976)

G-UR.3.2. Associated and Nonassociated Equipment. - A device shall meet all performance requirements when associated or nonassociated equipment is operated in its usual and customary manner and location.
(Added 1976)

G-UR.4.2. Abnormal Performance. - Unstable indications or other abnormal equipment performance observed during operation shall be corrected and, if necessary, brought to the attention of competent service personnel.
(Added 1976)

G-N.2. Testing with Nonassociated Equipment. - Tests to determine conditions, such as RFI, that may adversely affect the performance of a device shall be conducted with equipment and under conditions that are usual and customary with respect to the location and use of the device.
(Added 1976)

Note that G-N.2. states that when testing with nonassociated equipment only "usual and ordinary" equipment may be used and that devices may be tested only under conditions that are usual and customary for their operation and service.

The Normal Test described above should be repeated with all sources of EMI/RFI that are present under normal operating conditions. All fluorescent lighting and electric motor-driven appliances and generating devices installed at the station should be turned on. In addition, a vehicle should be parked in the position appropriate for a delivery with its motor and any additional appliances (like an air-conditioner) turned on.

4. Antidrain Means

As you know, the purpose of the discharge nozzle antidrain means is to prevent the hose from being drained at the completion of a delivery. If the antidrain means is not functioning properly, the next delivery may not include all the fuel that has passed through the meter and the customer will be charged for product that he or she has not received. Note that the LMD Code requires that wet hose devices, like gas pumps, be equipped with means such as this to prevent draining of the hose between deliveries.

S.3.7. Antidrain Means. - In a wet-hose, pressure-type device, means shall be incorporated to prevent the drainage of the discharge hose.
(Amended 1990)

A simple test ensures that the antidrain means is operating properly. With the dispenser turned off, place the tip of the nozzle in an appropriate container and open the discharge valve. A small amount of fuel that remains in the nozzle ahead of the antidrain means may dribble out, but this flow should be only momentary. Then raise about three feet of the hose immediately behind the nozzle connector so that it is higher than the nozzle. If fuel flows when the discharge valve is opened, the antidrain means is malfunctioning.

5. Zero-Setback Mechanism

Once the dispenser has been turned off, it should not be possible to dispense fuel until the dispenser has been reset to zero. This is intended to prevent a subsequent delivery from being added to the indicated volume and price of the preceding one. The on-off control is therefore required to be interlocked with the zero-setback mechanism, so that the dispenser can not be turned on until the setback has been effected. In addition, it is required that means be provided to assure that the dispenser control switch can not be left in the on position after a delivery has been completed.

Requirements relating to the design of zero-setback mechanisms (S.2.5.) was described in the last chapter, under **Advancement and Return to Zero**. Note, also, that the LMD Code includes a user requirement (UR.3.5.), which requires that at the conclusion of a delivery the on/off lever must be placed in the OFF position, the zero-set-back interlock engaged (this should occur automatically when the dispenser is switched off), and the nozzle returned to its hanging position (unless all indicating and recording elements have returned to zero.)

> **UR.3.5. Steps After Dispensing.** - After delivery to a customer from a retail motor-fuel device:
>
> (a) the starting lever shall be returned to its shutoff position and the zero-set-back interlock engaged; and
>
> (b) the discharge nozzle shall be returned to its designed hanging position unless the primary indicating elements, and recording if the device is equipped and activated to record, have been returned to a definite zero indication.

Activate the dispenser and check the zero indication. Then attempt to return the nozzle to its hanging position, with its tip placed in the receptacle. It should be impossible to do this without first moving the on-off switch to the off position. (In some designs the control switch in the on position physically blocks the reinsertion of the nozzle; in others, the control is built into the hanger, and must be switched off in order to accept the nozzle.) In other designs there is a "flapper" switch in the nozzle receptacle which turns the dispenser off when the flap is engaged by the nozzle. The most common malfunction of this assembly results from wear or improper adjustment of the control lever stop, with the result that the on position does not obstruct the nozzle receptacle.

If this test is satisfactory, remove the nozzle and attempt to switch the dispenser on. If it is equipped with a separate reset control (sometimes key-operated), it should be impossible to move the on-off control lever to the on position until the reset mechanism has been activated, either at the dispenser or by authorization from the control console. If the control lever can be operated, the reset must be actuated automatically. If fuel can be dispensed without the dispenser being reset, there is a malfunction in the interlock mechanism.

In remote dispenser systems and single-product dual dispensers, the on-off switch activates a control valve. To test the function of this automatic valve, remove the nozzle and attempt to operate the device without switching the dispenser on. If fuel flows from the nozzle (excepting the small amount of residual liquid in the nozzle itself) the control valve is defective. Next, switch on another dispenser that is served by the same pump (the other side of the dual dispenser, multi-product dispenser, or another dispenser in the same remote system) and operate the discharge valve of the dispenser being tested. If fuel flows, this is also an indication of a malfunctioning control valve.

6. Power Loss Test (electronic systems)

Electronic systems are dependent upon a continuous power supply, not only for the operation of control components, but also for the maintenance of correct indications. During the course of a delivery, cumulative totals for the volume and price are stored in the electronic circuitry. If the electrical supply to these circuits is interrupted—even momentarily—this information could be lost.

For this reason, electronic systems are equipped with an auxiliary power source, usually a battery, so that in the event of a failure in the main power supply, indicating functions are maintained, at least long enough to complete pending transactions, and so that information on the transaction can be preserved, even if not displayed, for the duration of the power loss.

S.1.6.2. Provisions for Power Loss.

S.1.6.2.1. Transaction Information. *- In the event of a power loss, the information needed to complete any transaction in progress at the time of the power loss (such as the quantity and unit price, or sales price) shall be determinable for at least 15 minutes at the dispenser or at the console if the console is accessible to the customer.*
[Nonretroactive as of January 1, 1983.]

S.1.6.2.2. User Information*. - The device memory shall retain information on the quantity of fuel dispensed and the sales price totals during power loss.*
[Nonretroactive as of January 1, 1983.]

Testing the system's auxiliary power supply under performance conditions generally requires creating a main power loss by turning off circuit breakers to the dispenser(s) and any remote indicating or control devices. This can not be done without causing severe disruption to the operation of the entire station. For this reason, this test is not recommended for routine examinations. It may be conducted on the first examination of a system or device that is put into service for the first time, or in response to specific complaints. Most emergency and auxiliary power supplies are equipped with test circuits. These may be checked as an "audit" procedure in routine examinations.

To test the system's protection against power loss, main power should be shut off first to any remote devices. This should be done by a station employee while the inspector simulates a delivery, dispensing product into a test measure or other suitable container. Indications at these devices should then be observed for at least 15 minutes. Correct indications should be maintained and be readable during this period.

The next step is to restore main power to remote devices and shut off main power to the dispensers. Sufficient power should be available from the auxiliary source to accurately maintain indications for at least 15 minutes without loss of data.

Finally, main power should be cut off to both dispensers and remote devices simultaneously, and maintenance of indications and stored data for a period of 15 minutes observed.

Testing Blended-product Dispensers

Figure 6-7 is an excerpt from the Test portion of the EPO for blended-product dispensers (an entire copy of EPO 22 is in the back of your notebook). As you can see by comparison, items 4-9 correspond exactly to procedures (though numbered differently) just described for single-product dispensers. A closer look at the first three items will show that the differences in testing procedure for this type of dispenser are in the sequence and repetition of certain steps, and reflect the special design features and operating characteristics of this type of device.

A blended-product dispenser is really two dispensing units. One unit delivers high grade product, the other low-grade product. Either unit may be operated independently, or both may be operated simultaneously, combining high- and low-grade product in the discharge nozzle to produce an intermediate grade. So tests of the operating performance must cover each unit operating independently and both units operating together.

Item 1 applies a Normal Test and Special Test (slow flow) to the unit that measures and delivers the lowest grade of product. The procedure is exactly the same as for a Normal Test and Special Test on a single-product pump.

Item 2 applies a Normal Test and Special Test to the unit dispensing the highest grade, exactly as in Item 1.

Under Item 3, the Special Test (slow flow), is applied to the operating condition in which both units are operating simultaneously. The selector should be set at the middle grade for the first test. Again, the procedure is the same as for single-product dispensers, except that it is repeated (at different intermediate settings) if the results show an error that is greater than the average of errors observed in Items 1 and 2.

Item 3.4. The computing device in blended-product dispensers, whether electronic or mechanical, is far more complex than its counterpart in a single-product dispenser. It must integrate volume totals for both dispensing units and compute a price that will vary for each different blend available. For this reason, money-value computations must be checked for all blends. (These checks will have been made for at least the highest and lowest grades, and middle blend in Items 1-3, so only the remaining blends must be tested.)

The procedure is the same as that described above as part of the Normal Test for single-product dispensers, except that these checks may be made after only one indicated gallon has been delivered. Measurement errors need not be recorded for these drafts.

Remember that blended products used for tests must be returned to the storage tank for the lowest grade dispensed.

FIGURE 6-7. BLENDED PRODUCT DISPENSERS EPO, TEST SECTION

Excerpts from EPO 22 Test Section

1. Test at lowest grade. Set selector control so that lowest grade product is dispensed.
   Normal test—full flow, basic tolerance .....N.1.1., N.2., N.3.4., N.4.1., T.2., UR.2.2.
   At the beginning of the first delivery, check for suppressed values. .....S.1.6.1.
   If first test result is at or near the tolerance limit, repeat this test. T.3., N.4.1.2

   Petroleum Product Sampling[1] Lowest Octane.

2. Test at highest grade. Set selector control so that highest grade product is dispensed.
   Normal test—full flow, basic tolerance .....N.3.4., N.4.1., T.2.

   If this test is at or near tolerance limit, repeat this test. .....T.3.

   Petroleum Product Sampling[1] Highest Octane

3. Test at blend. Set selector control at intermediate blend. Special test--slow flow, basic tolerance .....N.4.2., N.4.2.2., T.2.

   If this test result is at or near the tolerance limit and the error is the same as or greater then the average error of the previous tests, repeat this test .....T.3.
   Otherwise, slow flow test at first blend above lowest grade and first blend beneath highest grade.

   Petroleum Product Sampling[1] Blended Product

   Return blended product to the storage tank containing the lowest octane

[1] When taking gasoline samples from blended product dispensers, the samples should be collected after an observed sale of the particular grade or product to be tested, or sufficient product should be purged from the hose to ensure the sample is representative of the grade or product being sampled. The National Conference on Weights and Measures policy on procedures for taking samples for octane verification is as follows: **"A minimum of a liter (0.3 gallon) of engine fuel shall be flushed from the dispensers before taking a sample for octane verification. This flush shall be returned to the storage tank containing the lowest octane."** (see NCWM Publication 21, Petroleum Products Sampling Procedures and Safety Manual, August 1997).

SUMMARY

The Test portion of an official field examination involves procedures to determine whether the dispensing system performs within established tolerances. Tolerances are the limits of inaccuracy that are considered acceptable for a metering system in the commercial marketplace. Before the Test is conducted, the inspector must make Pretest Determinations to establish applicable tolerances and other factors relating to the Test. The Test itself comprises several separate tests. Some are intended to test the system's performance over its full range of operating characteristics. Others are intended to determine whether specific elements of the system, like the antidrain valve, are functioning properly. Tests are performed under conditions that approximate as closely as possible the conditions under which the equipment is normally used. Test procedures for single-product and blended-product dispensing systems differ in details, but are fundamentally similar.

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CHAPTER 7

POST-TEST TASKS

CHAPTER OBJECTIVES

Upon completion of this Chapter, you should be able to:

1. Review and evaluate results of the field examination to determine compliance.

2. Determine the appropriate compliance action based upon evaluation of examination results.

3. Describe administrative procedures for notifying the owner of the action taken and any steps that must be taken to bring devices into compliance.

4. Describe procedures for affixing security seals, inspection stickers, and other markings.

5. Understand procedures for completing and submitting report forms and other documentation.

INTRODUCTION

After you have completed all the steps outlined in the Test portion of the EPO, several post-test tasks remain to be performed. Some of these are specified at the end of the EPO, shown in Figure 7-1, but a few additional steps are necessary to complete the examination from an administrative point of view.

* *

Excerpts From EPO With Post Test Considerations

7. Security means
   a. check for/apply security seal ..... G-UR.4.5.
   b. record audit trail information ..... S.2.2.(c) (1/1/95) , Table S.2.2. (1/1/95)

Record the number of gallons of product dispensed during test on the official report.

Avoid switch loading!
Test devices dispensing low-vapor pressure products (e.g., diesel fuel, kerosene)
Before testing devices dispensing high-vapor pressure products (e.g., gasoline)

After all equipment at a location has been tested,
review results to determine compliance with equipment
maintenance and use of adjustments ..... G-UR.4.1., G-UR.4.3.

FIGURE 7-1. EPO, POST TEST TASKS

To summarize, the major post-test tasks include:

- installation of the security seal on the meter adjustment mechanism (if removed);
- recording audit trail information, if equipped
- evaluation of all examination results;
- determination of appropriate compliance action;
- notification of the owner of the device(s) of examination results;
- marking the device(s) to indicate approval or rejection; and
- completion and submission of examination report forms and other required documentation.

These post-test tasks will be described in the remaining sections of this chapter.

THE SECURITY SEAL AND AUDIT TRAIL INFORMATION

There is generally no need to remove the security seal that protects the meter adjustment mechanism in the course of a routine examination. If, however, you are examining a dispenser for the first time since its installation, or if you are re-examining after required adjustments have been made, or if the seal is damaged or broken, you will have to install a new seal. In addition, many jurisdictions use dated seals or tags that are sealed, and these must be installed after each examination.

The security seal could be of the lead-and-wire type consisting of a wire that is threaded through a hole in the moveable element of the adjustor and a hole in the body of the adjustor, whose position is fixed. An example of this installation is shown in Figure 7-2.

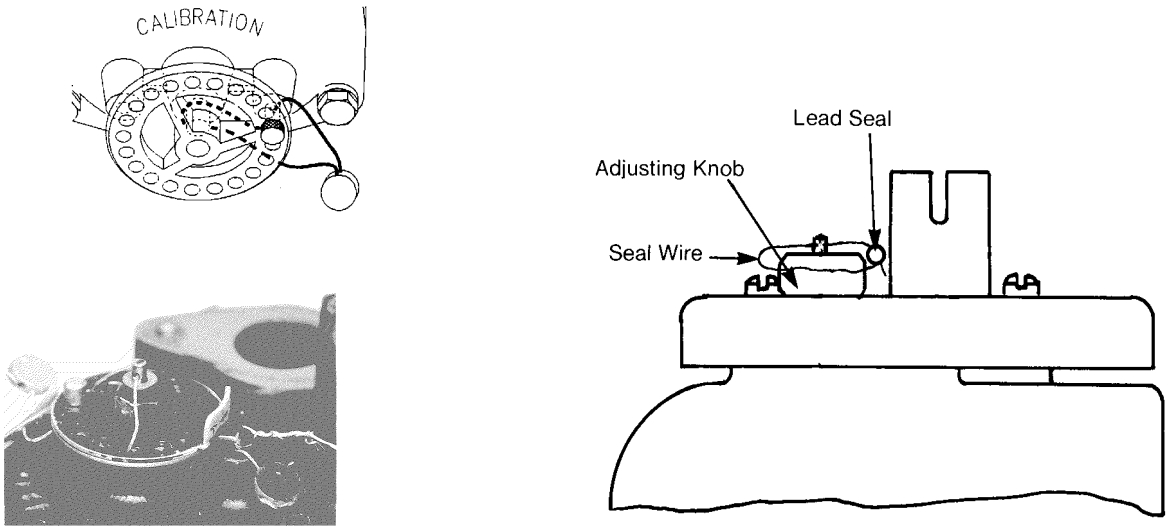

FIGURE 7-2. INSTALLING THE SECURITY SEAL

The two ends of the wire are then enclosed in a lead seal, using a special applicator. Your instructor will demonstrate the use of this tool in the classroom session devoted to this chapter. Some security seals are made of plastic material or they may be of a pressure sensitive material. (Procedures for their application are similar.)

When the security seal is properly installed, it should not be possible to move the adjusting element without either cutting the wire, or mutilating or destroying the seal. Multiple product, two-product, blended-product, and some single-product dual dispensers have more than one metering devices. Make sure that a security seal is installed on each meter adjustment in the dispenser.

For devices equipped with an audit trail you should record information provided by the audit trail for the device; for example, the numbers shown on the event counters. This information can be compared with the information contained the audit trail at the time of the next examination of the device; this comparison will indicate how many adjustments and changes have been made to the device since the last inspection. This information can be used as an enforcement tool to indicate whether or not further investigation into the use of the device is warranted.

Procedures for accessing audit trail information typically differ from manufacturer to manufacturer; different models produced by the same manufacturer may also use different procedures. Instructions for gaining access to audit trail information are provided in the owner's manual for the device and, for devices covered by an NTEP Certificate of Conformance this information should also be provided in the Certificate.

EVALUATING EXAMINATION RESULTS

Throughout the Inspection and Test you will have recorded results for each item. Since approval or rejection will depend upon these results, you should at this point review all items and identify any for which non-compliance has been determined. The most efficient means of doing this is to use a checklist that indicates compliance or non-compliance with each requirement, specification, or performance tolerance examined.

The report form used by your jurisdiction may provide such a checklist. If it does not, or if the list is not sufficiently comprehensive or specific, you may wish to adapt the Examination Procedure Outline for use as a checklist, attaching a page for summary of specific items of non-compliance.

RECORDING TOTALIZER READINGS

During the course of the Test, you will have recorded totalizer readings for each dispenser at the beginning and end of each test draft. As explained earlier, information on the total quantity of product dispensed from each dispenser during the examination, along with the total computed price, must be provided to the operator so that inventory figures can be reconciled (totalizers will indicate that a number of gallons of product have been delivered, even though all test liquid has been returned to the appropriate storage tanks).

The quantity delivered from each dispenser and the total prices for individual deliveries should be summed, and the results should appear on the official report form that is given to the operator at the conclusion of the examination. If the system is equipped with an electronic control console, be sure to indicate whether individual deliveries were made with the console set to "credit" or "cash."

DETERMINATION OF COMPLIANCE ACTION

Your evaluation of examination results should provide the basis for determining the appropriate compliance action. Separate determinations must be made for each device examined at a location, including such auxiliary devices as control consoles and ticket printers, as well as for specified features, such as the marking of fill connections for storage tanks.

Terms such as "correct," "incorrect," "approve," "reject," "condemn," etc. used in the text below are generic in nature and may vary from one jurisdiction to another.

A device is either "correct" or "incorrect." If all items to be checked during the inspection of the device are in conformance with the requirements of NIST Handbook 44, and the device meets all the requirements of the applicable tolerance tests, the device is correct. Note that a device can be accurate without being "correct." For example, a device that meets applicable accuracy requirements, but does not comply with other Handbook 44 specifications and requirements is not "correct." The owner or operator may correct some items during the examination, such as dirt on the glass over the indicator; however, these items must always be noted on the written report so that your jurisdiction has a record of the "as found" condition of the device.

If the device is correct, approval is written on the test report. A copy of the report is given to the establishment. Most jurisdictions require owners or operators to sign the report form as proof that they have seen it. In many jurisdictions, an approval notice or seal is placed on the device in some conspicuous location. This seal serves as an assurance that the device is suitable for use in its present location and that it was accurate when tested.

If, during the inspection or test, you determine that the device is incorrect (it is not accurate or does not meet all applicable requirements), it should be rejected (or condemned). The report given to the owner or operator should state that the device may not be used in commercial service until all unsatisfactory conditions (listed in the report) have been corrected and the device reexamined. A rejection tag should be attached to the device.

A rejection removes the device from commerce. It cannot then be used commercially until corrections have been made and the device reexamined. Only a weights and measures official may remove the rejection tag and

place the device back in commerce (unless that authority is delegated to a repair agency or the device owner by the official).
When the device is rejected it usually remains under control of weights and measures until it has been reinspected and approved. Normally, a rejected device should be repaired within a period of time specified by the inspector. If the repair is not made within the specified time, you may choose to seize the device or a part of it (such as the indicating element) that would make the device unusable.

Another reason for seizing a rejected device is to use it as evidence in a court case should your jurisdiction decide to take formal action against an owner or operator. In this instance, your jurisdiction may require you to issue a receipt to the device owner.

The NIST Handbook 130 Uniform Weights and Measures Law states that the director of weights and measures "shall condemn and may seize the weights and measures found to be incorrect that are not capable of being made correct."

Therefore, if, after rejection, a device is found to be either impractical or impossible to adjust or repair, it should be condemned and, if necessary, destroyed. Condemnation might also be appropriate in a case where a device has been seized and has not been claimed by a repair agency within the prescribed time frame.

It should be noted that condemnation is a last resort. When deciding what action to take, keep in mind that your goal is to provide accuracy in the marketplace. You have an equal responsibility to the buyer and to the seller and should strive to make a decision that will not cause an unnecessary hardship to either party.

NOTIFYING THE OWNER OR OPERATOR

When you have determined an appropriate compliance action, you must notify the owner or operator of the disposition and discuss it with him or her. The owner of the device must understand:

- why the action is being ordered;
- what will happen as a result of the order (temporary or permanent removal from service, physical removal, condemnation, etc.);
- what actions must be taken to bring the equipment into compliance;
- when corrections must be completed and the date and procedure for re-examination; and
- the consequences of failing to comply with the compliance order.

You must give the owner or operator a copy of the official inspection report that indicates specific items of non-conformance. That person should sign the report to establish its receipt; this signature does not necessarily indicate that he or she accepts the findings.

You should make every effort to explain specifically and in detail what is wrong with the device and what must be done to correct it. It is <u>not</u>, however, your responsibility to troubleshoot mechanical or electrical problems or recommend specific repair procedures, and you should avoid doing so. Under no circumstances should you make repairs or adjustments yourself. If the compliance order must be approved by your supervisor or some other official, indicate the recommendation you will be making and explain exactly what will happen if that

recommendation is approved. If the owner can request reconsideration or appeal of a compliance order, you should explain the procedures for doing so.

Remember that your purpose is to ensure that accurate and correct devices are used in the marketplace, not to mete out punishment for violations by administrative means. You must avoid imposing unreasonable or excessive burdens on sellers of products and services, keeping in mind that all costs of compliance actions will ultimately be borne by the consumer.

MARKING THE DEVICES

As mentioned above, each device examined should bear some indication of the date of the examination and the disposition (approval or rejection, etc.). Appropriate markings (stickers, tags, seals, etc.) affixed to the device or in some other conspicuous place provide assurance for customers and protect them from accidental or deliberate use of nonapproved equipment. This marking should be performed immediately upon your determination of disposition and before you leave the examination site.

Your instructor will show you the various markings used by your jurisdiction, and tell you how and where each of them should be applied.

REPORT FORMS AND RECORDKEEPING

Your instructor will show you how to complete the examination report forms that are used by your jurisdiction, and will tell you how and when they should be submitted. In addition, other types of documentation or information may be appropriate. Examples of such additional recordkeeping are logs of telephone calls, conversations, or written correspondence with owners, repairpersons, and supervisors. You will also find it useful to keep notes of problems encountered in the field and the compliance history of particular devices or service stations.

Accurate, systematic, legible, and comprehensive recordkeeping is as important a part of your job as the correct use of test equipment, mastery of examination procedures, or knowledge of codes and regulations.

SUMMARY

The last phase of an official field examination begins with an evaluation of results from the Inspection and Test. On the basis of this evaluation, a decision is made to approve or reject the device. In general, the system must be both “accurate” and “correct” to receive approval. Several nonapproval compliance actions are available. Once the decision is made, the owner or operator must be notified of the compliance action, and must receive an official written report of the examination along with sufficient explanation by the inspector to provide him or her with a clear understanding of the condition of the equipment, the steps that must be taken to remedy any deficiencies, procedures for any follow-up testing or certification required, and the consequences of failure to comply with the weights and measures order issued. The device(s) examined must be properly sealed, tagged, or marked to indicate their compliance status to the public and secure adjustable elements that could affect the accuracy of the system. Finally, the inspector must complete report forms and other record keeping tasks and submit this documentation to the jurisdiction, as required.

EPO No. 21

Examination Procedure Outline for

Retail Motor-Fuel Dispensers
Single, Dual and Multi-Product
(Except Blenders)

It is recommended that this outline be followed for conventional, single and dual product, power-operated retail dispensers--"gasoline pumps," analog or digital, and consoles. This outline may also be used for multi-product dispensers that share a single hose but not including those that dispense blended products. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the "Safety Considerations" section and the "Glossary of Safety Key Phrases" should be duplicated and included with the outline.

The inspector is reminded of the importance of evaluating potential safety hazards prior to an inspection and taking adequate precautions to avoid personal injury or damage to the device. The inspector should read and be familiar with the introductory section on safety found at the beginning of this publication. As a minimum, the following safety precautions should be noted and followed during the inspection. Definitions of each reminder are found in the "Glossary of Safety Key Phrases" at the back of this publication.

Safety policies and regulations vary among jurisdictions. It is essential that inspectors or servicepersons be aware of all safety regulations and policies in place at the inspection site and to practice their employer's safety policies. The safety reminders included in this EPO contain general guidelines useful in alerting inspectors and servicepersons to the importance of taking adequate precautions to avoid personal injury. These guidelines can only be effective in improving safety when coupled with training in hazard recognition and control.

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location
also: **Wet/Slick Conditions, Chemicals, Hazardous Materials, Petroleum Products, Obstructions**

Material Safety Data Sheets (MSDS)

Nature of Product

Personal Protection Equipment
e.g., Safety Shoes, Safety Aprons, Gloves, Barrier Cream, etc. if deemed necessary

Safety Cones/Warning Signs

Static Discharge

Switch Loading

Traffic

Transportation of Equipment

EPO No. 21

Inspection:

Safety First !!!

Check the inspection site carefully for safety hazards and take appropriate precautions.

Learn the nature of hazardous products used at or near the inspection site – obtain and read copies of MSDS's.

Know emergency procedures and location and operation of fire extinguisher and emergency shut-offs.

Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.

Use caution in moving in wet, slippery areas.

Use personal protection equipment and clothing appropriate for the inspection site.

Open both sides of dispenser to allow fumes to dissipate before proceeding with the inspection of the dispenser.

If leaks, spills, or exposed wiring cause hazardous testing conditions it is recommended that the testing be discontinued until the unsafe conditions are corrected.

Be sure that a first aid kit is available and that it is appropriate for the type of inspection activity.

H-44 General Code and Liquid-Measuring Devices Code References

1. General considerations
   - Selection ..... G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3.
   - Installation ..... G-S.2.,G-UR.2.1.,G-UR.2.2., UR.2.1., UR.2.4.
   - Position of equipment ..... G-UR.3.3.
   - Accessibility ..... G-UR.2.3.
   - Assistance ..... G-UR.4.4.
   - Use and maintenance ..... G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.3.5.

2. Indicating and recording elements.
   - Design ..... S.1.1.
   - Units ..... S.1.2.1., S.1.2.3.(a)
   - Readability ..... G-S.5., G-S.6.(1/1/77), G-S.7., S.1.4., S.1.5.
   - Values of intervals ..... G-S.5.3., G-S.5.3.1.
   - Indication of delivery S.1.6.1.,
   - Money-value divisions
     - Analog ..... S.1.6.5.1.
     - Digital ..... S.1.6.5.2.
     - Auxiliary indications S.1.6.5.3. (1/1/85)
   - Unit Price and product identity ..... S.1.6.4.1.(a), S.1.6.4.2., UR.3.2.
   - Multiple unit price dispensers ..... S.1.6.4.1.(b) (1/1/91), S.1.6.5.(a) (1/1/91), S.1.6.5.4. (1/1/91), UR.3.3.

Inspection (cont.):

Advancement and return to zero.....S.1.3., S.1.6.3., UR.3.1.
Recorded representations, point of sale systems.....S.1.6.7. (1/1/86)
Provision for sealing.....G-S.8. (1/1/90), G-UR.4.5., S.2.2.(a&b), S.2.2.(c) (1/1/95) Table S.2.2. (1/1/95)

3. Marking.....G-S.1.,G-UR.2.1.1.,G-UR.3.4., S.4.1., S.4.4.1. (1/1/85), S.4.4.2. (1/1/03)

4. Measuring elements.
   Air eliminator vent, if self-contained dispenser.....S.2.1.
   Security seal on adjusting mechanism.....G-UR.4.5.

5. Discharge hose-retail.....S.3.1., S.3.2., S.3.3., S.3.5.(b), S.3.6., UR.1.1.
   Marinas and Airports.....UR.1.1.2.

6. Totalizers.....S.5. (1/1/95)

Pretest Determinations:

1. Tolerances.
   Applicable requirements.....G-T., T.1.
   Basic values.....T.2.

2. Product storage identification.....UR.2.5.

Test Notes:

Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from splashed product.

Do not leave an activated dispenser unattended !

1. If test measure is dry, add 16.4 milliliter (one cubic inch) to gauge reading to allow for amount of liquid required to "wet" measure.

2. Hand held test measures require a 30-second ($\pm$ 5 s) pour followed by a 10-second drain, with the measure held at a (10 to 15) degree angle from vertical. (see NIST HB 105-3, Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards, 1997, Section 7).

Test Notes (cont.):

Ground test measure properly and only use a metal funnel when returning product to storage.

3. To determine proper operation of totalizers, read and record the totalizer indications before and after all test drafts. S.5. (1/1/95)

4. After each test draft:
   a. print ticket if device is so equipped.....G-S.5.6., S.1.6.7. (1/1/86), UR.3.4.
   b. check price computations on all indicators (including consoles) and on recorded representations. .....S.1.6.5.(a) (1/1/91)
      digital equipment .....G-S.5.5.
      analog equipment.....S.1.6.5.(b), N.4.3.2.
   c. check for agreement between indicators .....G-S.5.2.2., S.1.6.6.(a), S.1.6.6.(b) (1/1/88)
5. Verify, after a delivery is completed, that the quantity and total price are displayed for at least 5 minutes or until the next transaction S.1.6.5.5. (1/1/94)

Test:

Use proper lifting techniques when lifting test measure !

Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.

Be aware of vehicular and pedestrian traffic when moving between dispenser and storage tanks.

1. Normal test—full flow, basic tolerance .....N.1.1., N.2., N.3.4., N.4.1., T.2., UR.2.2.
   At the beginning of the first delivery, check for suppressed values. .....S.1.6.1.
   If first test result is at or near the tolerance limit, repeat this test. .....T.3., N.4.1.2.

   Petroleum Product Sampling[1]

[1] When taking gasoline samples from single hose multi-product dispensers, the samples should be collected after an observed sale of the particular grade or product to be tested, or sufficient product should be purged from the hose to ensure the sample is representative of the grade or product being sampled. The National Conference on Weights and Measures policy on procedures for taking samples for octane verification is as follows: **"A minimum of a liter (0.3 gallon) of engine fuel shall be flushed from the dispensers before taking a sample for octane verification. This flush shall be returned to the storage tank containing the lowest octane."** (see NCWM Publication 21, Petroleum Products Sampling Procedures and Safety Manual, August 1997).

Test (cont.):

2. Special test--slow flow, basic tolerance ..... N.4.2., N.4.2.2., T.2.

3. RFI/EMI test (electronic equipment only) ..... G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.

   Radio Frequency Interference (RFI)
   Electromagnetic Interference (EMI)

4. Check effectiveness of anti-drain means ..... S.3.7.

5. Check effectiveness of zero-setback interlock. ..... S.2.5.
   On equipment with remote pumping systems, activate one dispenser and check all others operated by the same pump to make certain they will not operate without activating the individual starting levers.

6. Power loss test ..... S.1.6.2.1.(1/1/83), S.1.6.2.2. (1/1/83)

   Check with your supervisor before requiring shutdown of power to equipment under test.

7. Security means
   a. check for / apply security seal ..... G-UR.4.5.
   b. record audit trail information ..... S.2.2.(c), (1/1/95) Table S.2.2. (1/1/95)

Record the number of gallons of product dispensed during test on the official report.

Avoid switch loading!
Test devices dispensing low-vapor pressure products (e.g., diesel fuel, kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline).

After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments ..... G-UR.4.1., G-UR.4.3.

Take precautions to isolate equipment when transporting it to avoid exposure to hazardous fumes.

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EPO No. 22

Examination Procedure Outline for

Retail Motor-Fuel Dispensers
Blended Product

It is recommended that this outline be followed for blending-type, power-operated retail dispensers--"gasoline pumps," analog or digital, and consoles. Nonretroactive requirements are followed by the applicable date in parentheses.

SAFETY NOTES

When excerpting this Examination Procedure Outline for duplication, the "Safety Considerations" section and the "Glossary of Safety Key Phrases" should be duplicated and included with the outline.

The inspector is reminded of the importance of evaluating potential safety hazards prior to an inspection and taking adequate precautions to avoid personal injury or damage to the device. The inspector should read and be familiar with the introductory section on safety found at the beginning of this publication. As a minimum, the following safety precautions should be noted and followed during the inspection. Definitions of each reminder are found in the "Glossary of Safety Key Phrases" at the back of this publication.

Safety policies and regulations vary among jurisdictions. It is essential that inspectors or servicepersons be aware of all safety regulations and policies in place at the inspection site and to practice their employer's safety policies. The safety reminders included in this EPO contain general guidelines useful in alerting inspectors and servicepersons to the importance of taking adequate precautions to avoid personal injury. These guidelines can only be effective in improving safety when coupled with training in hazard recognition and control.

Clothing

Electrical Hazards

Emergency Procedures

Eye Protection

Fire Extinguisher

First Aid Kit

Grounding

Ignition Sources

Lifting

Location
also: **Wet/Slick Conditions, Chemicals, Hazardous Materials, Petroleum Products, Obstructions**

Material Safety Data Sheets (MSDS)

Nature of Product

Personal Protection Equipment
e.g., Safety Shoes, Safety Aprons, Gloves, Barrier Cream, etc. if deemed necessary

Safety Cones/Warning Signs

Static Discharge

Switch Loading

Traffic

Transportation of Equipment

EPO No. 22

Inspection:

Safety First !!!

Check the inspection site carefully for safety hazards and take appropriate precautions.

Learn the nature of hazardous products used at or near the inspection site – obtain and read copies of MSDS's.

Know emergency procedures and location and operation of fire extinguisher and emergency shut-offs.

Post safety cones/warning signs and be aware of vehicular and pedestrian traffic patterns.

Use caution in moving in wet, slippery areas.

Use personal protection equipment and clothing appropriate for the inspection site.

Open both sides of dispenser to allow fumes to dissipate before proceeding with the inspection of the dispenser.

If leaks, spills, or exposed wiring cause hazardous testing conditions it is recommended that the testing be discontinued until the unsafe conditions are corrected.

Be sure that a first aid kit is available and that it is appropriate for the type of inspection activity.

H-44 General Code and Liquid-Measuring Devices Code References

1. General considerations.
   - Selection ..... G-S.3., G-UR.1.1., G-UR.1.2., G-UR.1.3.
   - Installation ..... G.S.2, G-UR.2.1., G-UR.2.2., UR.2.1., UR.2.4.
   - Position of equipment ..... G-UR.3.3.
   - Accessibility ..... G-UR.2.3.
   - Assistance ..... G-UR.4.4.
   - Use and maintenance ..... G-UR.3.1., G-UR.4.1., G-UR.4.2., UR.3.5.

2. Indicating and recording elements.
   - Design ..... S.1.1.
   - Units ..... S.1.2.1., S.1.2.3.(a)
   - Readability ..... G-S.5., G-S.6. (1/1/77), G-S.7., S.1.4., S.1.5.
   - Values of intervals ..... G-S.5.3., G-S.5.3.1.
   - Indication of delivery ..... S.1.6.1.
   - Money-value divisions
     - Analog ..... S.1.6.5.1.
     - Digital ..... S.1.6.5.2.
     - Auxiliary indications S.1.6.5.3. (1/1/85)
   - Unit Price and product identity ..... S.1.6.4.1.(a), S.1.6.4.2., U.R.3.2.

Inspection (cont.):

Multiple unit price dispensers	S.1.6.4.1.(b) (1/1/91), S.1.6.5.(a) (1/1/91), S.1.6.5.4. (1/1/91), UR.3.3.
Advancement and return to zero	S.1.3., S.1.6.3., UR.3.1.
Recorded representations, point of sale systems	S.1.6.7. (1/1/86)
Provision for sealing	G-S.8.(1/1/90), G-UR.4.5., S.2.2.(a&b), S.2.2.(c) (1/1/95), Table S.2.2. (1/1/95)

3. Marking G-S.1., G-UR.2.1.1., G-UR.3.4., S.4.1., S.4.4.1. (1/1/85), S.4.4.2. (1/1/03)

4. Measuring elements.

Air eliminator vent, if self-contained dispenser	S.2.1.
Security seal on adjusting mechanism	G-UR.4.5.

5. Discharge hose-retail ..... S.3.1., S.3.2., S.3.3., S.3.5., S.3.6., UR.1.1.
   - Marinas and airports ..... UR.1.1.2.

6. Totalizers S.5. (1/1/95)

Pretest Determinations:

1. Tolerances.

Applicable requirements	G-T., T.1.
Basic tolerance values	T.2.

2. Product storage identification ..... UR.2.5.

Test Notes:

Wear appropriate personal protection equipment such as petroleum-resistant, nonskid safety shoes (to prevent possible injury from spills or slipping on slick surfaces), protective clothing, and eye protection to prevent injury from splashed product.

Do not leave an activated dispenser unattended !

1. If test measure is dry, add 16.4 milliliters (one cubic inch) to gauge reading to allow for amount of liquid required to "wet" measure.

2. Hand held test measures require a 30-second ($\pm$ 5 s) pour followed by a 10-second drain, with the measure held at a (10 to 15) degree angle from vertical.

Test Notes (cont.):

(see NIST HB 105-3, Specifications and Tolerances for Graduated Neck Type Volumetric Field Standards, 1997, section 7).

Ground test measure properly and only use a metal funnel when returning product to storage.

3. To determine proper operation of totalizers, read and record the totalizer indications before and after all test drafts. S.5. (1/1/95)

4. After each test draft:
   a. print ticket if device is so equipped ..... G-S.5.6., S.1.6.7. (1/1/86), UR.3.4.
   b. check price computations on all indicators (including consoles) and on recorded representations. ..... S.1.6.5.(a) (1/1/91)
      digital equipment ..... G-S.5.5.
      analog equipment ..... S.1.6.5.(b), N.4.3.2.
   c. check for agreement between indications ..... G-S.5.2.2., S.1.6.6.(a), S.1.6.6.(b) (1/1/88)
5. Verify, after a delivery is completed, that the quantity and total price are displayed for at least 5 minutes or until the next transaction S.1.6.5.5. (1/1/94)

Test:

Use proper lifting techniques when lifting test measure !

Be aware of and attempt to eliminate potential ignition sources in or near the inspection site.

Be aware of vehicular and pedestrian traffic when moving between dispenser and storage tanks.

1. Test at lowest grade. Set selector control so that lowest grade product is dispensed.
   Normal test—full flow, basic tolerance ..... N.1.1., N.2., N.3.4., N.4.1., T.2., UR.2.2.
   At the beginning of the first delivery, check for suppressed values. ..... S.1.6.1.
   If first test result is at or near the tolerance limit, repeat this test. ..... T.3., N.4.1.2.

   Petroleum Product Sampling[1] Lowest Octane.

Test (cont.):

[1] When taking gasoline samples from blended product dispensers, the samples should be collected after an observed sale of the particular grade or product to be tested, or sufficient product should be purged from the hose to ensure the sample is representative of the grade or product being sampled. The National Conference on Weights and Measures policy on procedures for taking samples for octane verification is as follows: **"A minimum of a liter (0.3 gallon) of engine fuel shall be flushed from the dispensers before taking a sample for octane verification. This flush shall be returned to the storage tank containing the lowest octane."** (see NCWM Publication 21, Petroleum Products Sampling Procedures and Safety Manual, August 1997).

2. Test at highest grade. Set selector control so that highest grade product is dispensed.
   Normal test—full flow, basic tolerance .....N.3.4., N.4.1., T.2.
   If this test is at or near tolerance limit, repeat this test.....T.3.

   Petroleum Product Sampling[2] Highest Octane

3. Test at blend. Set selector control at intermediate blend. Special test--slow flow, basic Tolerance.....N.4.2., N.4.2.2., T.2.

   If this test result is at or near the tolerance limit and the error is the same as or greater then the average error of the previous tests, repeat this test .....T.3.
   Otherwise, slow flow test at first blend above lowest grade and first blend beneath highest grade.

   Petroleum Product Sampling[2] Blended Product

   Return blended product to the storage tank containing the lowest octane

4. Check money-value computations on other blends. Set selector control at each of the remaining blends and dispense 1 indicated liter/gallon to check computed price .....UR.3.2.
   Digital equipment .....G-S.5.5.
   Analog equipment.....S.1.6.5.(b), N.4.3.2.

5. RFI/EMI test (electronic equipment only).....G-N.2., G-UR.1.2., G-UR.3.2., G-UR.4.2.

   Radio Frequency Interference (RFI)
   Electromagnetic Interference (EMI)

6. Check effectiveness of anti-drain means.....S.3.7.

7. Check effectiveness of zero-setback interlock.....S.2.5.
   On equipment with remote pumping systems, activate one dispenser and check all others operated by the same pump to make certain they will not operate without activating the individual starting levers.

8. Power loss test.....S.1.6.2.1.(1/1/83), S.1.6.2.2. (1/1/83)
   Check with your supervisor before requiring shutdown of power to equipment under test.

9. Security means
   a. check/apply security seal G-UR.4.5
   b. record audit trail information.....S.2.2.(c) (1/1/95), Table S.2.2 (1/1/95)

Record on the official report the number of gallons of product dispensed during test.

[2] When taking gasoline samples from blended product dispensers, the samples should be collected after an observed sale of the particular grade or product to be tested, or sufficient product should be purged from the hose to ensure the sample is representative of the grade or product being sampled. The National Conference on Weights and Measures policy on procedures for taking samples for octane verification is as follows: **"A minimum of a liter (0.3 gallon) of engine fuel shall be flushed from the dispensers before taking a sample for octane verification. This flush shall be returned to the storage tank containing the lowest octane."** (see NCWM Publication 21, Petroleum Products Sampling Procedures and Safety Manual, August 1997).

Test (cont.):

Avoid switch loading!
Test devices dispensing low-vapor pressure products (e.g., diesel fuel, kerosene) before testing devices dispensing high-vapor pressure products (e.g., gasoline).

After all equipment at a location has been tested, review results to determine compliance with equipment maintenance and use of adjustments .....G-UR.4.1., G-UR.4.3.

Take precautions to isolate equipment when transporting it to avoid exposure to hazardous fumes.

General Index

Index of References to Paragraphs in NIST Handbook 44

Liquid-Measuring Device Code (con't)

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UR.3.2. 5-25, 5-28
UR.3.3. 5-3, 5-32, 5-34
UR.3.4. 6-7, 6-9
UR.3.5. 6-19